SCHOOL SCIENCE AND MATHEMATICS

VOL. XXXVIII | MARCH, 1938 | WHOLE NO. 329

FADS, FACTS, AND PHYSICS[1]

BY KARL F. OERLEIN

State Teachers College, Indiana, Pennsylvania

On one side are those who would throw out entirely the traditional courses of high school physics and chemistry and replace them by "integrated" or survey courses. On the other side are those who are for the "status quo." The two camps are distinctly marked.

Now it is possible that two opposing groups discuss a problem and both arrive at wrong conclusions. Though, in this case neither side is dead wrong. Both have simply overstated the value of their ideas until the proportion of truth is small.

Let us briefly review a few pertinent self evident truths.

1. Various factors have been operating to increase the enrollment in our American high school. The net results of which have been to increase the range of intelligence and to multiply the needs of the pupil groups which must be served.

2. Although physics is a basic science it is not always an end in itself. One need not be a mechanical engineer to be an intelligent consumer of automobiles.

3. That, if the reasoning, medicine is medicine is wrong, the statement that physics is physics is equally incorrect. If a little is good, more may not be better, in fact, it may prove fatal.

4. Other things being equal those knowing least about a subject are least able to teach it. However, the converse, is not necessarily true.

It is upon these points that I rest my case.

[1] Read at the Annual Pennsylvania Conference of College Physics Teachers, October 30, 1937, State College, Pa.

The misunderstanding between the two camps arises, I believe, in this way. The surveyists, let us call them, recognized the need for general survey courses and attempted to write the textbooks and material for the courses. Now, the early surveyists came mostly from the field of education and their science was none too good. Inaccuracies, distortions and false generalizations were common. The specialists, let us call them, coming upon these poor exhibits concluded that survey courses were bad.

It is my belief that the surveyists are right in recognizing the *need* for survey courses but they go wrong when they think themselves competent to write the course material. On the other hand, I believe the specialists are right in condemning inaccurate science, but they go wrong in confusing the *need* for survey courses with the presentation of the courses.

That good acceptable survey courses can and are now being written, witness the physical science survey course at the University of Chicago. Let me hasten to add, that specialists, thoroughly trained in their particular fields, made it.

Recalling some of the poor survey textbooks and courses that have appeared and remembering how poorly some were taught, can we blame the specialist for suspecting that another fad had arrived from our educational centers? That behind this fad far too many inadequately prepared and poorly trained science teachers were covering up their deficiencies? In the past the scientific training of many who vigorously advocated survey courses was none too strong and again the specialist's suspicion was aroused as to the true motive of the surveyists.

What of the traditional high school physics and chemistry courses? For those students whose professional goal is already decided and who need them, we should continue to provide the traditional type courses. Although this group is small, since it furnishes our future engineers, physicians, and other technical leaders, adequate provisions must continue for them. However, for those who because of lack of ability are unable to profit by the traditional type or for those whose formal education ends with graduation from high school, I believe improved survey type courses to be superior in meeting their needs. I cannot agree that the same type courses will suffice for both kinds of students. College departments of physics recognized differentiation in their subject. Some departments offer as many as five

different first courses.[2] We cannot permit students to graduate from high school without having had, at least, an appreciation course in the physical sciences. Think of calling any one liberally educated who has missed an entire branch of human knowledge!

Because of the greater number of needs to be served we should increase the number of types of science courses offered. It is not necessary to change traditional physics and chemistry courses to survey type. We need additional types rather than changed types of courses.

And this brings up the question: What shall be the training of a high school teacher of physics and the physical sciences? Whether he is to teach the traditional or the survey type courses the modern science teacher needs more science—less method. He should, of course, have some meaty educational courses for the purposes of professional direction and evaluation and to be able to fit into a modern school system intelligently. But education courses can never be a substitute for science.

What a catastrophe to see students in a science class working on contract systems, project methods or filling in blank spaces in workbooks. Instead, the teacher should be working with the pupils using bits of string, candles, pins, tin cans, wires, jars and a hundred other odds and ends. Imagine trying to develop the scientific attitude, conceded to be the cardinal objective of science teaching, without recourse wherever possible to simple experiments, the very soul of the scientific method!

Consider these two extreme types of teachers. First, the young lady fresh from college who was just able to pass that dreadfully hard course in college physics because of the mathematics. She never was any good at mathematics anyway. She is teaching the course because in order to get the job in English she had to accept physics too. Second, we have the young man fresh from the graduate school. He has but recently emerged from a confined research room after many months of painstaking labor on his dissertation study of some spectral effect of an uncommon organic compound. He is teaching in high school because no industrial research position was open at the time. Somewhere between these two extremes lies the proper training for a teacher of physics and the physical sciences in the secondary school.

---

[2] Oerlein, K. F.: "Variability in the First Courses in General College Physics." *Am. Physics Teach.*, V: 80–82 (April 1937).

The type of teacher we need is one willing to roll up his sleeves, use a soldering iron and get his hands dirty on occasion. He is interested in the problems of life as well as the subjects he teaches. He has a hobby such as radio, photography, telescope making which he pursues with vigor. He is able to suggest many lines of science activity within the range and ability of his class and to the members of the science club which he sponsors, not because he has to, but because he wants to. He understands boys and girls and can work for and with them. He possesses a contagious enthusiasm for and a genuine interest in the subject he teaches. He is not a genius but his I.Q. is on the right side of normal. In short, we need in our science classes today, indeed in our whole educational system, more master teachers.

Now I cannot agree with those who say that master teachers are born—not made. I believe such teachers can be developed. But I wouldn't think of building a master teacher on anything less than a thorough foundation in the field in which he is to teach. And to my way of thinking, the preparation of teachers to successfully teach survey type courses must include, not less science, but more science in one field and more fields of science.

Let me illustrate the point. Picture this relatively common situation. In a physical science survey course the teacher has been discussing matter. He has talked about molecules, atoms, electrons, protons and neutrons. He gives the diameters, the masses and other statistical magnitudes. He probably resorts to several of a number of schemes to convey some idea of the magnitudes of these particles. If the teacher is successful he will have aroused at least some students and he may be faced with the inquiry,—"Well, if you can't see these things and they really are that small how do scientists measure them?" The way in which the teacher will handle this situation will indicate the type of teacher he is.

The inadequately prepared teacher, the one who has himself only had survey courses, will probably have to graciously excuse himself for his lack of information,—he cannot answer. The professional physicist might answer by deriving some mathematical equations from some highly concentrated physical assumptions and laws. In all probability he will swamp the student who asked the question and put the remainder to sleep. No student in that class will thereafter ever instigate such a catastrophe by venturing another question. Now the master teacher realizes that the student has caught fire—he is aroused

and is doing some thinking. The master teacher realizes, too, that the question is one of appreciation and the background of the students is not sufficient for a mathematical approach. He knows that the student doesn't want a dissertation but he does want an answer. The point is that the master teacher has had sufficient preparation not only to recognize an excellent learning situation when it arises spontaneously but *he has had the additional reserve science information* to know the correct answer. In addition, the master teacher has acquired the art of accurate simplifications and correct generalizations. With the knowledge of a scientist, the resourcefulness of a trained teacher and the skill of an artist, the master teacher presents in a series of simple basic steps sufficient information to develop an appreciation of the method and perchance induce the student to pursue the subject further. The student is satisfied.

Finally, one more thought in closing. Perhaps the specialists, those in favor of the traditional courses, have some misgivings concerning the future of their subjects should survey courses continue to increase in popularity. I am confident the demand for survey courses will cause an increase in the necessity for the traditional type also. However, whether we like it or not survey courses are here to stay. But the matter assumes a rather comical aspect. For, consider; the surveyists have started something which they are not qualified to finish and they must call upon the very ones whom they oppose to rescue their survey courses. On the other hand, the specialists because of the demand, will be compelled to work up the material for the very courses which they condemn. Out of it, of course, will come a better understanding between the two groups. The surveyists will become scientific minded and the specialists will appreciate the educational problems involved.

BARTHOLD A. IVERSON

"Mr. Barthold A. Iverson, 54, for nearly thirty years a member of the Plymouth (Wis.) High School faculty, died of a heart attack Dec. 8. Mr. Iverson taught his classes the morning of his death and drove home for lunch, seemingly in the best of health. It was there that he was stricken."

—Taken from the *Wisconsin Journal of Education.*

DIET EXPERIMENTATION AS A STUDENT PROJECT IN THE HIGH SCHOOL BIOLOGY DEPARTMENT

By R. Will Burnett
Concordia High School, Concordia, Kansas

It has appeared to many teachers of biology in the high school that the largest part of student project work in the biology course is waste effort. Projects of the usual twig collection and leaf print type not only represent material which has little future value as teaching aids but involve practically no thinking on the part of the student, no learning of a fundamental concept nature, and hence little educative value.

Fig. 1

In an attempt to allow student participation in meaningful project work a series of diet experiments were conducted last school year in the Concordia High School. Although checked by the instructor the work was carried out entirely by students of the three biology classes and a few members of the chemistry class who helped in the mixing of the diets.

White rats were used in these experiments and were housed in a multiple cage which was constructed by biology students as a project. Four students worked upon this cage. A sketch plan was drawn up by the instructor indicating the number of compartments desired and the size of these compartments. Other

suggestions were given but the details of the work and the plans were left to the students. The resulting cage is shown in the accompanying photograph made by a student of the chemistry department. With ten compartments, size 20″ by 20″ by 11½″ and one compartment size 20″ by 20″ by 22″ the cage serves nicely in housing experimental animals as well as the usual number of heterogeneous animals ordinarily brought into the biology classroom during the course of the school year. The

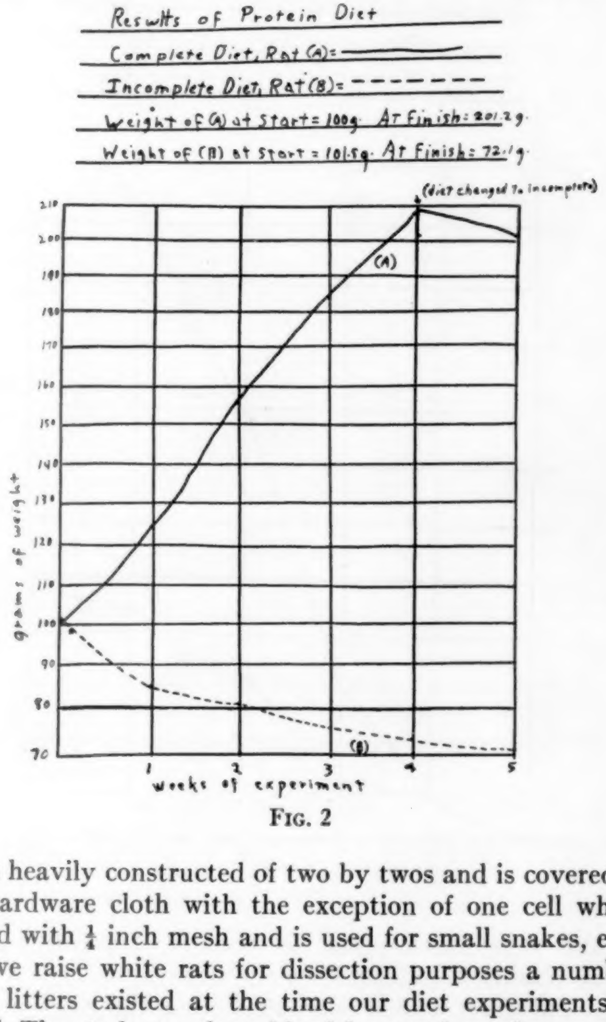


FIG. 2

cage is heavily constructed of two by twos and is covered by ½ inch hardware cloth with the exception of one cell which is covered with ¼ inch mesh and is used for small snakes, etc.

As we raise white rats for dissection purposes a number of young litters existed at the time our diet experiments were started. The students selected healthy rats from the same litter and of course of the same sex.

It was originally decided to experiment with diets deficient in protein, carbohydrates and vitamins. Due to the fact that the proper vitamin deficient materials could not be obtained the vitamin deficient experiment was not conducted.

The diets were developed by student committees from each

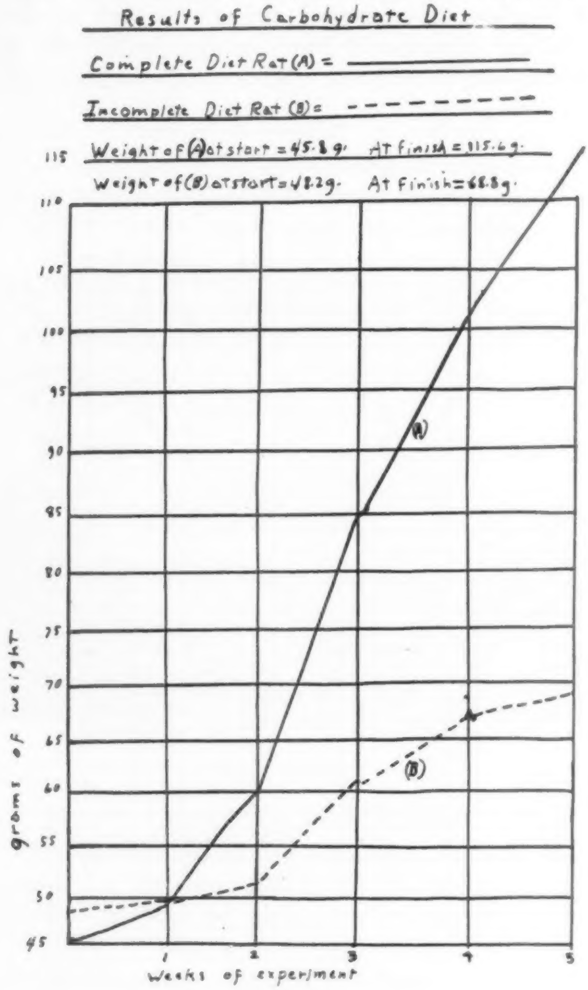


FIG. 3

class and were based upon the booklet, *Laboratory Experiments in Nutrition*, published by the General Biological Supply House The diets varied somewhat from the ones suggested there, but were essentially the same The protein complete diet was made up as follows:

32 parts milk
60 parts corn starch
3 parts lard
1 part salt
2 parts calcium carbonate
2 parts yeast
40 drops cod liver oil per 1,000 grams of diet.

The protein deficient diet was made up as follows:

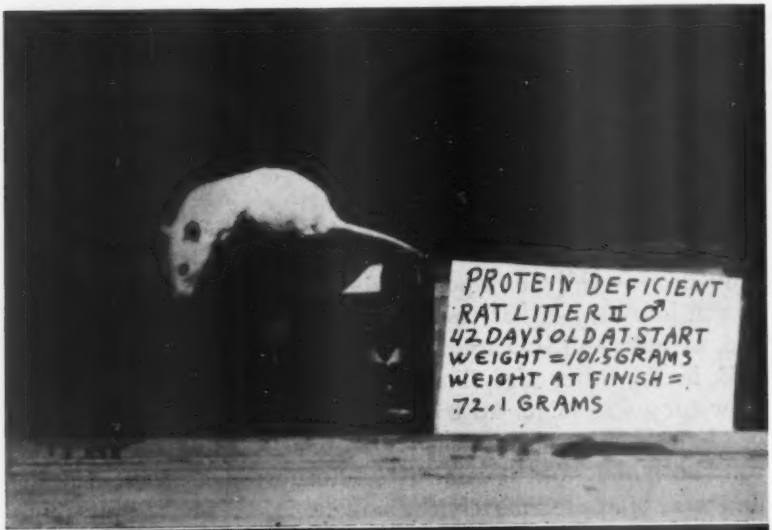
92 parts starch
3 parts lard
1 part salt
2 parts calcium carbonate
2 parts yeast
40 drops cod liver oil per 1,000 grams of diet

It will be noticed that the only variance in the diets is in the lack of milk and its casein in the one and the presence of this milk in the other diet To provide the same bulk, the weight deficiency was made up by adding more starch

The rats selected for this experiment were 42 days old and were both males of the same litter. Both were in excellent health and were of approximately the same weight. (At the first weighing they differed by just .5 gram but due to food and water intake, urination and defecation their weight varied by as much as several grams during the day.) Each rat was given a scrupulously clean cage, a pan of clean water and a pan of their respective diets. The cages were cleaned each day and food and water replenished daily. The rats were weighed in once each week for five weeks by students of each of the 3 classes. All of the students kept records of the following: original weight of each rat, loss or gain of weight of each rat, total difference in weight between the rats, general appearance and activity of each rat. They also constructed graphs showing the weights by weekly intervals.

The effects of the difference in diet were immediately apparent. The weight of the protein deficient rat immediately dropped while the weight of the protein complete rat rose. Little difference was ever apparent in the activity and appearance of these rats save that the deficient diet rat showed an unkempt coat and the face became more and more wizened. At the end of a four week period the diet of the protein complete rat was changed to that of the protein incomplete with an immediate drop in its weight. The diets were not crossed for any length of

time because the rats themselves were wanted as specimens to indicate to future classes the results of the diet difference in a concrete form. At the end of the experiment conclusions were written up by the students, the rats were photographed by a



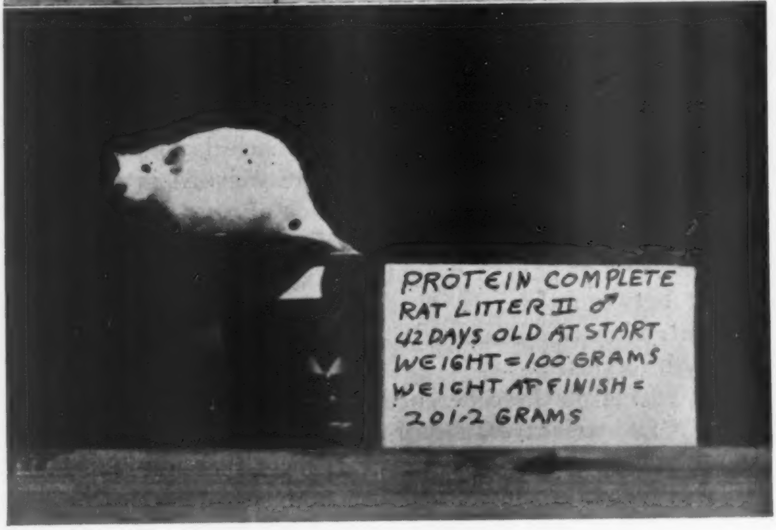
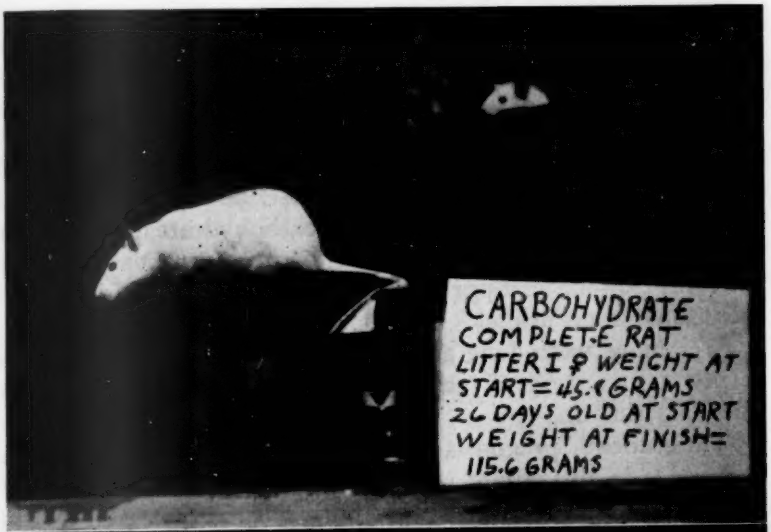


FIG. 4. Above FIG. 5. Below

student and were then turned over to a biology student who, together with other biology students, had learned taxidermy as a means of preparing better project material. (Each year those

who are interested are given mimeographed sheets of taxidermal instructions and are given help by the instructor in learning to mount animals competently. In this manner our school museum is continually being enlarged.) This student mounted the



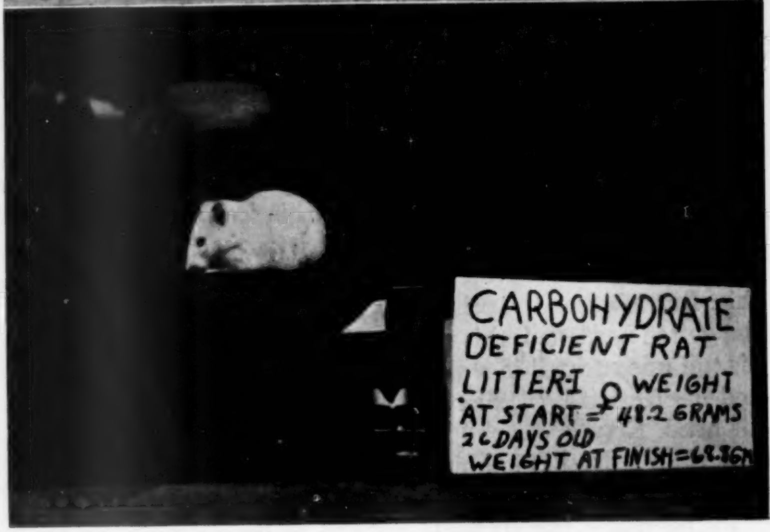


FIG. 6. Above FIG. 7. Below

rats on small boards which were attached to a large display board which also shows pictures of the rats and gives the complete diet of each rat as well as graphs showing their gain or

loss in weight. The pictures of the rats as they appeared at the conclusion of the experiment are submitted as is a graph indicating the difference in their rate of growth. The interest compelling feature of the entire display, however, is the mounted rats with their incontrovertible, if mute, evidence of the value of a well rounded diet.

The carbohydrate diet was conducted upon the same plan. The rats used were of the same litter and were both females, 26 days old. The carbohydrate complete diet was as follows: 30 parts casein, 60 parts starch, 5 parts butter, 1 part salt, 2 parts calcium carbonate, 2 parts yeast, and 40 drops of cod liver oil per 1,000 grams of diet. The carbohydrate deficient diet was as follows: 90 parts casein, 5 parts butter, 1 part salt, 2 parts calcium carbonate, 2 parts yeast, and 40 drops of cod liver oil per 1,000 grams of diet.

Weighings were done at weekly intervals and the students kept the same type of records as they had done in the protein diet experiment.

The students' prognosis that there would not be as extreme a difference in the rate of growth as in the protein diet was, of course, correct. The diets were both adequate in protoplasm building materials but one lacked the energy producing carbohydrate. Hence examination of the rats' activities and general appearance was, in this case, more enlightening than the following of the changes in weight. The carbohydrate deficient rat was found to be extremely quiet and apparently very lazy. Three or four times it was necessary to clean the mass of gluten from his feet and tail. He would get his feet and tail wet and then drag them thru his food which was in the form of a powder. For that matter, all of the rats would occasionally do this. But whereas the other rats would clean themselves before the gluten hardened, this rat would allow it to accumulate until his tail was encased in a glass-like sheath twice as big as his tail and his feet had "boxing gloves" of gluten nearly as large as his head. He was cleaned, incidentally, by the only method we could think of: soaking him in warm water up to his belly and then carefully cracking off the hardened food.

Furthermore the students noticed while cleaning the cages that the urine of this rat was very dark and possessed a strong odor. So for one week neither cage was cleaned so that a superficial examination of the wastes could be made. At the end of that time the odor of the urine from the carbohydrate deficient

rat's cage had become noticeable for several feet around the cage.

It was interesting to note the students' attempt at explaining these results. Some real thinking and studying was done at this point by many of the students and most of them explained the results rather satisfactorily. Of course the oxidizing of protein to release energy (necessitated by the complete lack of carbohydrates in the diet) involved the production of nitrogenous wastes in large amounts. Removed by the kidneys it necessitated large amounts of urine and it was heavily charged with these wastes. It was obvious to all why the rat was so lethargic. But his extreme weakness and inertia came as a surprise to all including the instructor.

Photographs of these rats as they appeared at the end of the experiment and a graph of the weekly change in weight of the two are shown.

In evaluating this project as a pedagogical device the following points stand out to a much greater degree than they ordinarily do in project material:

1. It required clear thinking and organization on the part of those students conducting the experiment.
2. It required analysis and consideration by the entire biology department.
3. It integrated a number of separate projects into a meaningful whole.
4. It motivated and interested the entire biology department.
5. It was a direct outgrowth of a classroom problem and was turned back to the classroom for conclusions to be drawn, hence, it had high educative value.
6. It gave the department a number of permanent teaching aids of value.

For this reason I consider the project highly successful and worth continuing and enlarging upon in future classes.

The Eli Lilly and Company research award for 1937 has been given to Dr. Frank L. Horsfall, Jr, for research on one phase of the chemistry of immunity. The award consists of a bronze medal and a cash prize of $1,000, to be given annually to a young man or woman under 31 for research of merit in the fields of bacteriology or immunology. Dr. Horsfall conducted his investigations at McGill and Harvard universities and in the hospital of the Rockefeller Institute for Medical Research in New York.

ELECTRICITY AND CHEMISTRY—SOME DEMONSTRATION EXPERIMENTS

By Charles H. Stone
Orlando, Florida

The history of electricity is a long chapter. It began, we may suppose, when the first lightning flash blazed across the murky sky of our primordial earth. For centuries, men knew nothing as to the real nature of electricity. The Greeks, that marvelous people of early recorded history, knew something of certain electrical effects and gave us a name for what they believed to be the far-darting arrows of war-making Jove.

From the kite of Franklin down to the work of Morse, Bell, Edison, Marconi, and many others is a tale that would fill great numbers of volumes. Only recently, however, has a real understanding of the nature of the electric current been arrived at since it has been shown that it is really a migration of electrons, a determination made possible by the investigation of the constitution of matter and a study of the structure of the atom. Today we know pretty well what the constitution of the atoms is, and the identity of matter and energy as essentially electrical has been established.

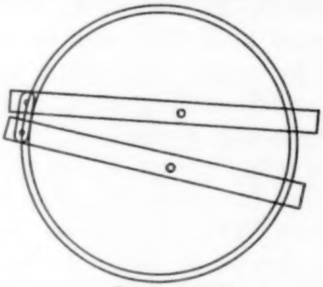
The application of some of the more elementary ideas concerning the electric current as applied to chemistry may be found in a series of simple experiments adapted for class demonstrations. All of the following experiments have been repeated time without number in the writer's classes, and can be repeated anywhere, since the apparatus required is very simple and easily assembled.

A. Electrolytes and non-electrolytes.

Procure a glass dish of a diameter of about three to four inches and an inch and a half deep. Such dishes may be purchased at one of the well known ten-cent stores at two for five cents. These dishes are round and are called "berry dishes." Since acids and bases are to be used in the following work, a metal dish will not answer unless it has been coated with shellac or paraffin all over the inside.

Prepare also two strips of wood about one-half inch square and five inches long. Bore a hole at the middle point of each piece; this hole should be of a size just large enough to admit an iron nail of large size, but the nail should fit snugly. Arrange

some sort of hinge at one end of the two pieces so that they can be opened or shut like a nut-cracker. (See Fig. 1.)



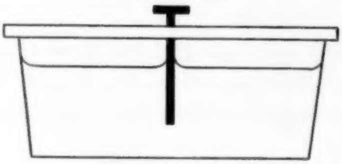


FIG. 1

Insert two bright clean nails into the two holes and connect the nails by wires to the lighting circuit; there should be an electric lamp in the circuit. Place the wood strips across the top of the glass dish.

1. Pour water into the dish until the nails are immersed in the liquid to the depth of about an inch. Does the lamp glow?

2. Add a few ml. of dilute sulphuric acid. Does the lamp presently glow? Why does it not glow instantly?

3. Pour out the liquid from the dish and refill with water. Does the lamp glow? If it does, it shows that some liquid was carried over on the nails from the first solution. This emphasizes the importance of rinsing off or wiping off the electrodes after each test.

4. Fill the dish again with water and insert the electrodes. Now add a few ml. of dilute nitric acid. Repeat, using dilute hydrochloric acid. Repeat, using oxalic acid solution. Repeat, using acetic acid. Tabulate your observations as below:

Solvent	Solute	Lamp
Water	Water	Does not glow.
Water	Sulphuric acid etc.	Glows brightly.

The glow when acetic acid is used is very faint because this acid is only feebly ionized. All the other acids used are more or

less highly ionized. The more ions there are in the solution the greater can be the flow of current.

5. Clean the electrodes and repeat the above exercises using solutions of potassium hydroxide, sodium hydroxide, barium hydroxide, calcium hydroxide, ammonium hydroxide. How do you account for the marked falling off in brightness of the lamp when ammonium hydroxide is used?

6. Swing the two strips in such a way as to bring the electrodes nearer and then farther apart, using $HC_2H_3O_2$ solution. What do you observe? What explanation can you make as to the variation in the glow of the lamp. As the distance between electrodes diminishes, the light increases. State this fact in the form of a definite formula.

7. Raise the nails through the holes so that only about half of their original surface is now in the liquid. What is the effect on the glow of the lamp? State your conclusions in the form of a law.

8. Repeat experiments above, using solutions of such salts as: sodium chloride, potassium sulphate, lead nitrate, and other salts. Tabulate your results.

9. Remove the dish and place the wood strips across the empty dish. Lay a strip of iron across the two nail tops. How about the lamp? In similar manner, use strips of lead, tin, copper, zinc, aluminum. Try a stick of sodium with freshly scraped surface, holding the sodium with the tongs. Try a carbon rod. Tabulate results.

10. Repeat 9, using a stick of phosphorus held with tongs, a stick of sulphur, glass rod, wood ruler, etc. Tabulate results.

11. Fill the dish with glacial acetic, being sure the dish and the nails are dry. Does the lamp glow? Why? Remove much of the acid and add water. Does the lamp now glow? What do you conclude?

12. Dry the dish and nails and fill the dish with alcohol. Does the lamp glow? Repeat using glycerine, cane sugar solution in water, acetone, kerosene.

13. From your completed tabulation, make certain definite statements fully covering all cases.

14. Fused electrolytes. Fill a small evaporating dish with powdered potassium nitrate. Stand the dish on asbestos gauze on large ring stand. Arrange your strips of wood so that the dry nails dip deep into the powder. Does the lamp glow? Conclusions? Apply heat to the dish until the nitrate melts. Does

the lamp glow? What do you conclude? Consider now Hall's method for preparing aluminum. What was his fused electrolyte? On what principle do some of the electric furnaces operate?

B. Ion migration.

1. Make a solution of neutral common salt, five grams in 100 ml. water. Add a few ml. of phenolphthalein solution and shake well. Fill a U-tube with the solution up to half an inch of the side arms. Support the U-tube on frame as shown by Fig. 2. Insert the two electrodes, which may best be of platinum but clean bright iron nails will serve. Connect the two electrodes to the poles of a dry cell. After a few minutes a red color appears around one of the electrodes; this electrode is the cathode. When the solution was made, the dissolved salt broke up into positive sodium and negative chlorine ions.* Make it plain to

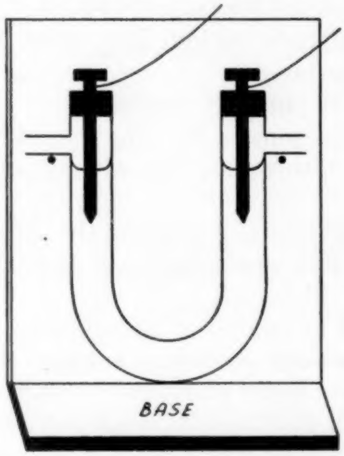


FIG. 2

your class that this happens when the solution was made and is NOT caused by the electric current; this point of view is to be emphasized for students often think that the current causes the ions to form. The sodium ions are unable to react with the water but are drawn toward the cathode or minus pole because unlike charges attract. Arrived at the cathode, the sodium ion takes off an electron and becomes a sodium atom. But sodium atoms can react with water to form sodium hydroxide and

* Modern research reveals that even dry salt has a lattice arrangement of sodium and chlorine ions. In the dry state, however, these ions are not mobile as they are in solution. Would you teach this to your beginners?

hydrogen. But sodium hydroxide is a base and all soluble hydroxides turn phenolphthalein red because of hydroxyl ion. On the anode side, the chlorine ions, being negative, are drawn toward the anode or plus pole; on arriving there, they give up their electrons and become chlorine atoms, free to dissolve in the water, to react with it to some extent to form hydrochloric acid, or to escape as chlorine gas when the liquid is saturated with chlorine.

2. Repeat the above, after washing out the U-tube and cleaning the electrodes, using a solution of potassium sulphate and phenolphthalein. Do you obtain similar results to those obtained in B. 1?

Repeat the experiment, but reverse the current. Where is now the cathode?

3. Replace the nails with a bright strip of copper for anode and a clean carbon rod for cathode. Fill the U-tube with a solution of copper sulphate; no indicator. After some minutes what appears on the carbon?

From the above you may conclude:

a. If the positive ions on reaching the cathode and becoming atoms can react with water, they will do so to form a base and liberate hydrogen.

b. If the positive ions on reaching the cathode and becoming atoms cannot act on water, they will plate the cathode and no hydrogen will be liberated.

c. Preparation of potassium persulphate. Make a saturated solution of potassium hydrogen sulphate in water. Fill the U-tube with it and insert platinum electrodes. A battery of dry cells in series will yield results much more quickly than will a single cell. If a direct-current lighting system is available, that may be used with a lamp in the circuit to introduce resistance. After a time, a white product will form in the U-tube which should be surrounded by cold water. The white product is potassium persulphate. $KHSO_4$ ionizes into K^+ and HSO_4^-. The latter combines to form persulphuric acid.

$$2HSO_4 \rightarrow H_2S_2O_8.$$

The potassium ions at the cathode form potassium hydroxide. The potassium hydroxide reacts with the persulphuric acid to form potassium persulphate.

$$2KOH + H_2S_2O_8 \rightarrow 2H_2O + K_2S_2O_8.$$

When a sufficient quantity of the white product has formed it may be filtered off and dried.

Instructors who attempt to teach the principles of electrolytic dissociation and the applications of electricity to industry by reference to the textbook only and by oral instruction will have hard sledding.

But the above series of experiments, accompanied by exhaustive questioning, will go far to illuminate and make more interesting a subject which the average beginner does not find an easy one to master.

PREVENTION OF JUVENILE DELINQUENCY FOR AN ENDURING AMERICA*

By Austin H. MacCormick
Commissioner of Correction, New York City

Those of us who have been dealing for years with the problem of delinquency and crime are confident that they can be reduced by slum clearance and new housing programs; the expansion of recreational facilities, both indoors and outdoors; increase in the number of clubs for boys and girls, community centers and similar agencies; improvement in our public school systems; extension of our public health programs; and by making the home, the school and the church into a triangular bulwark against those forces which attack our youth today.

No democracy can endure or deserves to endure that does not safeguard its children in whom its future strength lies. Humanity and common sense dictate that we bend every effort to prevent juvenile delinquency, which leads so surely to adult crime. Crime is a corrosive force which eats steadily into the sinews of society. Attacking it at its sources, by preventing juvenile delinquency will keep tens of thousands of Democracy's children from becoming her adult enemies.

Today, in the United States, young offenders make up a large percentage of all those arrested. These boys usually show a long history of juvenile delinquency beginning in early adolescence and unfortunately, in too many cases, a long subsequent history of adult crime. Practically all criminologists are agreed, however, that we could reduce crime substantially, especially that committed by young offenders, if we conducted campaigns of crime prevention as effective as our programs of preventive medicine.

The prevention of juvenile delinquency does not require the establishment of strange new agencies, or the use of new and bizarre techniques. It can be prevented by the expansion and improvement of agencies which are now available and the use of methods with which we are perfectly familiar. Our delinquents and criminals today come predominantly from the underprivileged groups, from the slums of our great cities, and the poorer parts of our smaller communities.

To such a program, socially-minded organizations of the country should commit themselves without delay. Especially is this true of women's organizations, for the welfare of our youth has always been close to their hearts. This assemblage can strike a mighty blow against crime by striking at its roots in juvenile delinquency.

* Abstract of address delivered at Thirteenth Women's Conference on National Defense for an Enduring America at the Mayflower Hotel, Washington, D. C., Wednesday afternoon, January 26, 1938.

SOLUTION OF THE QUADRATIC EQUATION BY MEANS OF COMPLEX NUMBERS

By John J. Corliss
De Paul University, Chicago, Illinois

The quadratic equation

$$ax^2+bx+c=0 \tag{1}$$

may be readily solved by complex numbers provided its roots are complex. We recall two facts from Algebra and Trigonometry. First any complex number z may be expressed in the equivalent forms

$$z=re^{i\theta}=r(\cos\theta+i\sin\theta),\ (i=\sqrt{-1}). \tag{2}$$

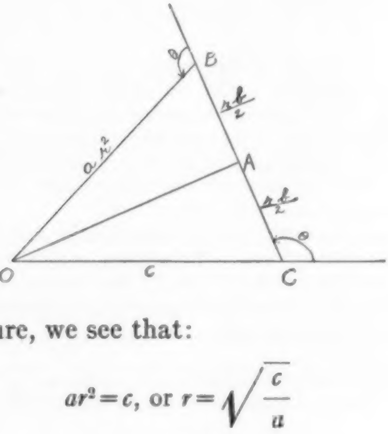
Second. The sum of two complex numbers is the diagonal drawn from the origin of the parallelogram whose sides are the complex numbers. Whence if the sum of three complex numbers is equal to zero, then they must form the sides of a triangle.

Assuming the roots of equation (1) complex and substituting from equation (2) gives

$$ar^2e^{i2\theta}+bre^{i\theta}+c=0. \tag{3}$$

The sum of these three complex numbers is zero, hence if c be taken horizontal then $bre^{i\theta}$ will make an angle of θ with c, and $ar^2e^{i2\theta}$ will make an angle of 2θ with it.

The figure will consequently be an isosceles triangle.



From the figure, we see that:

$$ar^2=c, \text{ or } r=\sqrt{\frac{c}{a}}$$

and

$$\cos(180^\circ-\theta)=-\cos\theta=\frac{\frac{rb}{2}}{c}$$

or

$$\cos\theta=-\sqrt{\frac{c}{a}}\cdot\frac{b}{2c}=-\sqrt{\frac{b^2}{4ac}}$$

also

$$\sin\theta=\pm\sqrt{1-\cos^2\theta}=\pm\sqrt{1-\frac{b^2}{4ac}}\,.$$

Substituting these values in equation (2) gives,

$$z=\sqrt{\frac{c}{a}}\left[-\sqrt{\frac{b^2}{4ac}}\pm i\sqrt{1-\frac{b^2}{4ac}}\right]$$

or

$$z=\frac{-b\pm\sqrt{b^2-4ac}}{2a}\,.$$

The formula thus obtained is true even though the roots are not complex.

Construction of Complex Roots

If the roots of (1) are complex, they may be represented geometrically thus.

Let

$$z_1=x_1+iy_1=-\frac{b}{2a}+\frac{i\sqrt{4ac-b^2}}{2a}$$

$$z_2=x_2+iy_2=-\frac{b}{2a}-\frac{i\sqrt{4ac-b^2}}{2a}\,.$$

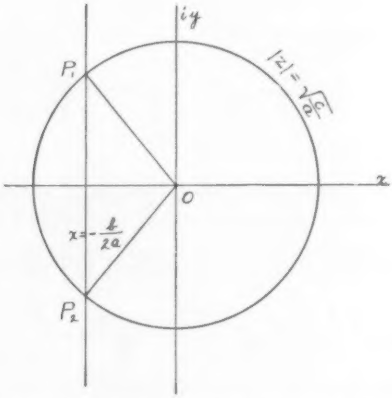
The moduli of z_1 and z_2 are $\sqrt{c/a}$
hence they terminate on a circle center at origin and radius equal $\sqrt{c/a}$ or on the circle

$$|z|=\sqrt{\frac{c}{a}}\,.$$

Further the real part of each is

$$x=-\frac{b}{2a}\,.$$

Hence the two complex roots of equation (1) are represented geometrically in magnitude and direction by the segments OP_1 and OP_2.



We are here of course picturing the complex roots in the complex plane, hence the vertical axis is denoted by iy.

ROUND TABLE DISCUSSIONS IN ARITHMETIC WORK

By C. R. Purdy, *Joseph Sears School, Kenilworth, Illinois*

To partly eliminate the criticism that our arithmetic classes are failing to do anything to socialize the pupils and also to bring about entire class participation in discussion of informational topics, I have found the round table discussion method very effective. This method of teaching is not new, especially to the social science field, and no doubt is used by many mathematics teachers, but I pass it along here in case there are those who haven't tried it in mathematics work.

The set up consists of choosing four topics of an informational nature, four leaders from the class, each to prepare in detail one of the topics, and some references to be read by all of the class on all four topics. On the day of the discussions, the leaders are stationed in the four corners of the room and the class is divided into four sections, each section spending a fourth of the period discussing a topic with one leader and then moving on the to next leader. I have found that it helps participation if each member of a group scores the rest of the group on citizenship, participation, and quality of information and every pupil also scores the leaders on their leadership qualities.

Nearly every unit of Junior High School work has topics that lend themselves to the method. Here are a few of the topics that we have tried: sales tricks used by unscrupulous merchants, calendar reforms, ways of cooperating in the family budget, cost of medicine and socialized medicine, cost of an education, best methods for investing savings, and numerous others.

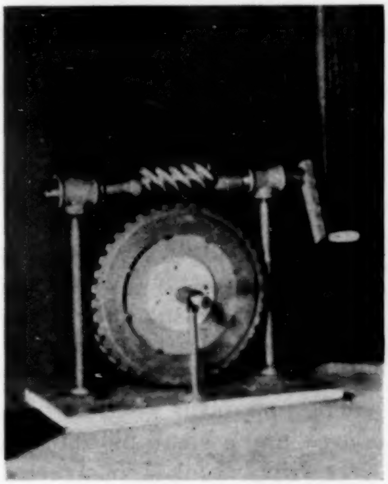
There are on the market several series of pamphlets in arithmetic topics that give plenty of material for this type of lesson. Some textbooks have sufficient material in their informational sections. There certainly is a wealth of material available in the free literature that can be obtained.

The educational significance of a well conducted lesson of this type is apparent and I find the interest and pupil growth most gratifying.

SPEED RATIO AND MECHANICAL ADVANTAGE OF THE WORM GEAR DRIVE

By F. W. Moody
Grover Cleveland High School, St. Louis, Missouri

Many of the high school Physics texts make mention of the worm gear drive used on the rear axles of motor trucks, following general discussions of the worm gear as given in science books for years, without pointing out an important distinction between the action of the two.



A Worm Gear

The worm gear, or worm wheel, has a shaft on which is cut a screw thread of the ordinary type with one continuous groove running around it. This is set tangent to, and in mesh with, a cogwheel so that one rotation of the screw advances the wheel the distance between two adjacent cogs. And if the wheel has n teeth, the worm must rotate n times for one rotation of the wheel.

In the worm gear drive however, the shaft does not have one continuous thread like the ordinary screw, but it is cut with several parallel grooves somewhat like those in a rifle barrel. The linear distance between successive threads on such a screw does not measure the pitch of the screw, but this distance must be multiplied by the number of parallel grooves on the shaft.

In the one shown, which we have set up in our laboratory, there are 39 cogs on the wheel and 6 parallel grooves on the shaft. The linear distance between threads of the worm is $\frac{7}{8}$ of an inch but the pitch of the screw is $5\frac{1}{4}$ inches. It takes $6\frac{1}{2}$ turns of the shaft to produce one rotation of the wheel.

Let n' be the number of parallel grooves of the worm, then the speed ratio is n/n' which is also its mechanical advantage.

REFLECTION OF LIGHT

By Arthur E. Cebelius
Teachers College of Connecticut, New Britain, Connecticut

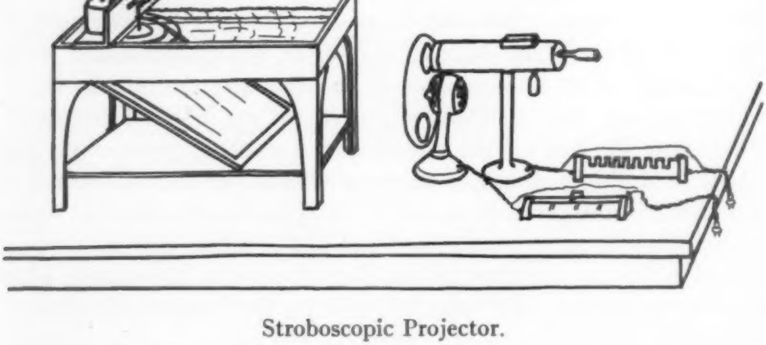
[This article is the introductory portion of a paper on reflection prepared by Mr. Cebelius for presentation before a class in "Physical Science for the Junior High School" of which he is a member. Mr. Cebelius is a Senior at the Teachers College of Connecticut. The object of this article is to illustrate types of laboratory activity pertinent to the subject being discussed. O. E. Underhill, Instructor in science.]

In considering the reflection of light, it is well to note that it can be explained on both the theory of corpuscles and the theory of waves. If light is composed of "minute, perfectly round and elastic bodies," as Newton set forth, "the reflection of light would then be the result of the bouncing of the particles, and would follow the law that the angles of incidence and reflection are equal. Perfectly elastic bodies, when shot at a reflecting surface, would bounce off that surface at the same angle as they struck, as shown by Newton."

However, to explain the reflection of light by the wave theory is more complicated. Some help may be gained by considering analogous phenomena in water waves.

The apparatus consists of a ripple tank, a mirror, a light source, and a small piece of glass or wood, about $3'' \times 5''$.

The ripple tank is constructed in the form of a shallow wooden tray with a waterproof glass bottom. The frame is made of wood, and is about sixteen inches long by twelve inches wide, by three inches deep [see figure].



Stroboscopic Projector.

Fill the tank with about a half inch of water, and support it on two ring stands, or other suitable support. Adjust the

mirror, which should be at least as large as the bottom of the tank, at an angle of forty-five degrees and place a light source before it. When the mirror is properly adjusted, light from the light source will be reflected through the glass bottom of the tank, through the half inch of water, and up to the ceiling of the room, where shadows of any wave on the surface of the water will appear.

We may show by analogy how waves in water may reproduce phenomena which also may be observed in the behavior of light. Place in the tank, a small piece of glass, or wood on its longest edge at a forty-five degree angle with one of the ends of the tank, so that the shadow of this reflecting surface is seen on the ceiling. Now make a train of waves travel from the other end of the tank toward the reflecting surface by gently placing a pencil-point in the water at that end. On the ceiling the wave train will be seen in shadow, travelling toward the reflecting surface, and when it strikes, the train can be seen to proceed from that point at right angles to the original direction. By changing the angle of the cardboard or glass, different directions will be shown.

At the same time that this demonstration is shown, it is well to show its analogy to the reflection of light waves in a plane mirror, by merely flashing light on a looking-glass, and noting the change of direction of the beam. In diagrams in which lines are used to represent rays instead of wave fronts this may be explained by assuming the lines to represent cross sections through a train of waves. They will pass through a particular point at which we choose to put our eye. All other lines would miss the "eye" so that it will not receive reflected light from any other direction.

In our ripple tank we can also show the reflection of waves by using a parabolically curved, reflecting surface formed from a strip of sheet lead. These effects may be shown stroboscopically. In order to do this, an ordinary electric bell is used to create a continuous train of waves in the ripple tank. Remove the gong, and cut off the extreme end of the clapper. At right angles to the clapper arm, solder a long finishing nail, so that the nail vibrates vertically when the bell is in a horizontal position. When this device is mounted thus, on a suitable wooden frame, this vertical motion will be the source of the water waves in our next demonstration. A circular shutter operated by an electric fan motor controls the light. Detach the fan blades,

and put in their place a disc of cardboard, about 10″ in diameter, with two holes, on opposite edges the same size as the arc light opening. Make the holes so that six times the diameter of the opening, will be approximately the circumference of the disc.

This stroboscope apparatus operates as follows. When the exciter (the electric "bell" with the vertical plunger) is set in motion, waves emanate from the point at which it touches the water in the tank. The shutter is started, and placed so that the holes in the disc will revolve before the arc light aperture. Thus, there will be alternate flashes of light and shadow striking the mirror and reflecting upward. When the speed of the shutter has reached the speed of oscillation of the exciter, a flash of light will be reflected through the water just as often as a new wave is made. In other words, for every wave there is a flash, and since the waves will be moving outward at a continuous rate, each wave is "flashed" in the same spot as the one preceding it was in the preceding flash. Consequently the pattern on the ceiling appears to stand still. This is known as "stroboscopic projection." By varying the speed of the fan motor with a rheostat, the waves can be made to move slowly backward or forward on the ceiling.

It is difficult to obtain a completely stationary pattern, due probably, to slight variations in the speed of the fan motor, but apparent motion can be slowed down until the armature of the bell appears to move up and down very slowly.

To show parabolic reflection, place at the end of the ripple tank opposite the exciter a parabolically curved strip of lead, or other metal made from a strip about sixteen inches long. Place the curve with the open end out, so that waves from the exciter will strike the inner surface of the curve, and reflect to a common center, which is the "focus" of the rays. With this apparatus, the stroboscopically projected shadows will show how waves are reflected to the focus, at which point a bright dot, or perhaps a larger ring, depending upon the speed of the stroboscope apparatus, will appear. Of course interference patterns are also set up. These tend to confuse the reflection phenomena but after a few minutes' practice the observer will be able to follow with the eye the initial wave front and its reflection. Reflection from the sides of the wave trough also set up interference patterns. The larger the trough the more these are eliminated. At least the reflection being observed through

the central portion of the trough will occur before the waves reflected from the sides of the trough have time to interfere.

In using this demonstration, care must be taken to give the students the idea of a water analogy to light waves. The fact that an extra source of light is used may confuse them. The light source is not the origin of the waves we wish to discuss. It merely serves to project the waves that we form in shadow upon the ceiling.

References

1. Cleveland, Frederick A. *Modern Scientific Knowledge.* Ronald Press Co. c. 1929 p. 146 Short study of "transverse waves in ether."
2. Jeans, Sir James. *The Mysterious Universe.* Macmillan Co. N.Y. c. 1930. p. 36—Newton's Principia, in part; adaptation of the "elastic, round corpuscles" to wave phenomena. p. 85—The ether as a medium for light waves.
3. Lemon, Harvey Brace. *From Galileo to Cosmic Rays.* University of Chicago Press. c. 1934 Chapters 35, 36, and 39. Wave phenomena in General—illustrations and photographs. The stroboscope in ripple tank, Doppler effect.
4. Robertson, John Kellock. *Introduction to Physical Optics.* D. Van Nostrand Co. N.Y. c. 1929. pp. 60–69. Complete explanation of reflection according to Huygen's Principle; Reflection internally and also wave propagation.
5. Stephanson, Reginald J. *Exploring in Physics.* University of Chicago Press. c. 1935 Chapter 12. Wave motions; reflections; propagation; the Doppler effect—diagrams and illustrations.
6. Webster, Farrell and Drew. General Physics for Colleges. Century N.Y. c. 1926 rev. ed. pp. 294–295, 650–652. Discussion of the older theories of light.

COLOR FILM FITTING ALMOST ALL CAMERAS GOING ON NATION WIDE SALE

Color photography by which the amateur can take pictures in his own cheap camera and obtain prints in colors is coming out of the laboratories of scientists and the professional photographer and entering the commercial stage.

Dufaycolor, Inc., in a demonstration have announced that their color film is now going on nation wide sale in all sizes for use in almost any size and style of camera, from the popular miniature models to the giant ones using 8 by 10 inch plates. Even the cheap small box cameras can use the new film.

The cost of the film was not announced but will be higher than ordinary black and white because the sales price will include cost of development of the film. The cost of color prints will depend on the volume of business handled by the special processing factory now being planned by Dufay. At present a print $2\frac{1}{4}$ by $3\frac{1}{4}$ inches costs 70 cents.

Agfa Ansco is known to be working on a color process film for amateurs in their laboratories. While the details have been secret it is known that Agfa has two goals: (1) a fast film equal in exposure speed to present black and white, and (2) a film which can be developed and processed by any amateur instead of at the factory.

FURTHER STUDY OF THE RELATIVE EFFICIENCY OF TWO METHODS OF APPROXIMATING THE ROOTS OF AN ALGEBRAIC EQUATION[1]

By Cecil B. Read
The Municipal University of Wichita, Wichita, Kansas

It would indeed be unusual if the first study of any problem yielded all the information which might be desired. In particular, if certain aspects of the problem were intentionally omitted, investigation of these aspects might be worth while.

The results of the first investigation of the relative efficiency of Horner's method of approximating the roots of an equation, as contrasted with the graphical method, were made available in 1935.[2]

Summary of Method of Approximating a Root of an Equation by Successive Graphs

A. From a graph of $y=f(x)$, estimate a root, $y=x_1$, correct to tenths.

B. By synthetic substitution locate the root between values of x differing by tenths. These values, $x=a$ and $x=b$, will be in the neighborhood of $x=x_1$.

C. Approximate the graph of $y=f(x)$ in the interval $x=a$ to $x=b$ by a straight line connecting the points $(a, f(a))$ and $(b, f(b))$, using an *enlarged scale.*

D. From the graph in C estimate a root correct to hundredths.

E. Repeat step B for values differing by hundredths, obtain $x=c$ and $x=d$.

F. Repeat step C for the interval $x=c$ to $x=d$. The scale is again enlarged.

G. Estimate a root correct to thousandths, possibly ten-thousandths, and continue the process until the desired accuracy is obtained.

A very definite advantage was found to exist in favor of the graphic method, both in the meantime required by the group

[1] Based upon Read, C. B. *Further Study of the Relative Efficiency of Two Methods of Approximating the Roots of an Algebraic Equation.* Unpublished Doctor's Field Study, Colorado State College of Education, Greeley, Colorado, 1937.

[2] Read, C. B. "Relative Efficiency of Two Methods of Approximating the Roots of an Algebraic Equation." School Science and Mathematics, Vol. 35, pp. 30–34 (January, 1935).

to solve a problem and in the time required for presentation of subject matter to the class. However, the study was definitely limited to computations involving results correct to three decimal places. While it is probable that most computations will not require greater accuracy than this, there will be occasions when more accuracy is required. Which method is more efficient under these circumstances? Likewise, the first study was limited to computations made by beginners. Do the same results hold for computations carried out by advanced students?

In an attempt to answer these two questions, it seemed best to follow the plan of the first study and carry out an experimental comparison of the two methods. Six sections of freshman algebra at the University of Wichita were utilized, divided into two groups of three sections each, the first group consisting of 74 students, the second of 68 students. To both groups, which will be referred to as Group A and Group B respectively, the standard course was presented until the subject in question was reached. At this time Group A was presented with the details of Horner's method, followed by the first form of the test. Then the graphic method was presented, followed by the second form of the test. With Group B the procedure was reversed, the graphic method being presented first. With both groups use was made of textbooks, class discussion, outside assignment, and board work. Teachers attempted to be as impartial as humanly possible in presenting the methods. Although in the previous study four class periods were given to Horner's method and only three to the graphic method, in this study each method received attention for four class periods.

The report of the previous study shows that the test used is somewhat unique in that it requires an answer free from error, the score being the time consumed. A simple check is available by which the accuracy of results may be ensured. Since the complete solution of the test problem to six decimal places is quite lengthy a continuing process was adopted, and used on both forms of the test. Students were instructed to solve the test problem, obtaining results accurate to two decimal places. As soon as the paper was received, it was given a partial score (the score is the number of minutes required, since a correct answer must be obtained). The paper was then returned to the student, with instructions to carry the work to three place accuracy, a partial score was again recorded, and the student instructed to carry to another place, and so on. This procedure

would seem to penalize the student who is unfortunate enough to make a mistake in the early stages of his work, for his score at the succeeding steps carries along the time spent in locating the mistake. However, it is felt that the number of students involved was large enough to make such penalties relatively insignificant.

Results of the computations for this rotation group experiment are shown in Table I.

TABLE I

MEAN TEST SCORES IN NUMBER OF MINUTES REQUIRED FOR A CORRECT ANSWER, WITH RESULTS OF COMPUTATIONS FOR THE ROTATION GROUPS EXPERIMENT

Measure	Number of decimal places				
	2	3	4	5	6
GROUP A—(Horner's method taught first)					
Using Horner's Method					
1. Mean M_{AH}	84.93	100.81	110.34	116.89	127.91
2. Standard deviation	14.20	16.20	16.80	17.90	19.82
3. Standard error of mean	1.65	1.88	1.95	2.08	2.24
Using Graphic Method					
4. Mean M_{AG}	56.35	90.34	127.36	151.76	168.18
5. Standard deviation	9.56	16.50	23.32	27.60	30.70
6. Standard error of mean	1.11	1.92	2.71	3.21	3.57
GROUP B—(Graphic method taught first)					
Using Horner's Method					
7. Mean M_{BH}	77.71	96.53	105.78	112.50	122.43
8. Standard deviation	13.54	17.00	18.80	18.70	20.90
9. Standard error of mean	1.64	2.06	2.28	2.27	2.35
Using Graphic Method					
10. Mean M_{BG}	55.00	87.57	126.49	147.87	163.82
11. Standard deviation	11.50	17.73	24.65	30.95	34.79
12. Standard error of mean	1.39	2.15	2.99	3.75	4.22
COMBINED SCORES					
13. $M_{AH}+M_{BH}$	162.64	197.34	216.12	229.39	250.34
14. Standard error of sum[1]	2.33	2.79	3.00	3.08	3.38
15. $M_{AG}+M_{BG}$	111.35	177.91	253.85	299.63	332.00
16. Standard error of sum[1]	1.78	2.87	4.04	4.94	5.52
17. Difference (13.−15.)	51.29	19.43	−37.73	−70.24	−81.66
18. Standard error of diff.[1]	2.93	4.00	5.03	5.82	6.47

[1] Since results of the previous study show very low correlations between scores by the two methods the shorter formula for standard error of a sum or difference was used.

Table I shows definite verification of the results of the first study, namely, that for three place accuracy, the graphic method yields accurate results with less expenditure of time

than Horner's method. For two decimal places, the graphic method shows an even greater advantage.

When more than three decimal places are required, the results show a direct reversal. For four places, the advantage becomes distinctly in favor of Horner's method; when we require five or six place accuracy, the advantage in favor of Horner's method becomes even more pronounced.

It is of course interesting to note the results of studies made regarding the beginning student, but much of the use of either method will of course be made by advanced students, such as engineering students, those in physical sciences, and mathematics majors. In an attempt to study this phase of the question, 148 students of junior or senior college rank, selected from the groups just mentioned, were used. All had previously received instruction in both methods. The students were informed that they might be expected to solve a problem by either method as a regular assignment, and were given an opportunity for review by library reference, although no class time was spent in discussion.

In order to obtain two groups as nearly matched as possible, two criteria were used for sectioning: (1) the raw score on the National Council on Education Psychological examination; (2) the average mark in all previous work in college mathematics. Other bases might have been used, but suitable criteria were not readily available. It seemed advisable to give each of the two criteria equal weight, the desired result being accomplished by forming a composite score, weighting each factor in proportion to the standard deviations. For the first group, designated Group A, the mean composite score was 754.45 and standard deviation 79.60; for the second, Group B, the mean composite score was 754.47 and standard deviation 79.80.

Group A was required to solve the test problem by use of Horner's method while Group B was instructed to use the graphic method. The same procedure of partial scores at varying degrees of accuracy was used. Results of the computations for these two groups of 74 students each are given in Table II. Inspection of the table shows that there is very little variation from the conclusions reached regarding the work of beginning students. The average times required for the advanced students were strikingly similar to those required by beginning students (it might be borne in mind that the beginning stu-

TABLE II

MEAN TEST SCORES IN NUMBER OF MINUTES REQUIRED FOR A CORRECT ANSWER, WITH RESULTS OF COMPUTATIONS FOR MATCHED GROUPS OF ADVANCED STUDENTS

Measure	Number of decimal places				
	2	3	4	5	6
1. GROUP A—Horner's Method					
2. Mean	81.89	97.09	106.55	112.03	132.64
3. Standard deviation	11.65	14.60	14.90	15.40	16.95
4. Standard error of mean[1]	.86	1.06	1.14	1.14	1.28
5. GROUP B—Graphic Method					
6. Mean	53.12	86.39	122.80	150.41	158.08
7. Standard deviation	10.40	16.15	23.39	28.30	30.90
8. Standard error of mean[1]	1.21	1.88	2.72	3.29	3.60
9. DIFFERENCE	28.77	11.70	−16.25	−38.38	−25.44
10. Standard error of diff.[2]	1.48	2.38	2.95	3.48	3.82

[1] The formula used was (S.D. $\sqrt{1-r^2}$) $\sqrt{N}$.

[2] The shorter formula for standard error of a difference was used.

dents had had much more practice immediately preceding the tests). The importance of the experiment would seem to lie in the fact that irrespective of whether the computations are performed by beginning or advanced students, the graphic method seems to be more efficient for results accurate to not more than three decimal places, while Horner's method tends to become increasingly more efficient for results accurate to four or more places. In all cases the difference found was statistically significant.

With such marked variations in the time required for the solution of a problem, the question naturally arises as to the cause for such variations. Both methods are the same up to the location of a root between consecutive integers, from there on the process varies widely. Since the mechanical work is essentially the same for any root, a study of the solution by which one root is obtained might yield a clue.

There are no complicated mathematical procedures, rather, a purely mechanical process of lengthy multiplications, with additions and substractions in connection. Hence a crude measure of the labor required might be obtained by counting the digits which must be written down in a solution by either method. This is not a complete measure of the difficulty, for it takes no account of the ease with which results may be checked,

nor does it consider the construction of simple graphs in the graphical method. However, the information given in Table III

TABLE III
NUMBER OF DIGITS WHICH MUST BE WRITTEN TO OBTAIN A SOLUTION

Accuracy required	Number of digits necessary	
	Horner's method	Graphic method
Two decimal places	132	48
Three decimal places	184	206
Four decimal places	210	438
Five decimal places	247	786
Six decimal places	387	1160

regarding the number of digits which must be written in order to obtain a root by each method may be enlightening. Apparently the graphic method requires less computation for two places, roughly the same at three places, but increases rapidly after that point. This no doubt gives some indication of the reason for the increased efficiency of Horner's method for many decimal places.

In the experiments described, students were required to obtain an answer free from error. Errors made were penalized by an extra amount of time consumed in locating them, since the score was the total time consumed. The question arises as to the types of errors committed when using either method.

In an attempt to answer this question, ninety students in three sections of freshman algebra were given as a test a problem from the textbook. The equation was a cubic with three real roots; thirty minutes were allowed for obtaining one root by Horner's method, then thirty minutes for obtaining a second by the graphic method. No attempt was made to grade the papers, rather, an effort was made to analyze the errors. It seemed quite apparent that every mistake in either method was due to haste or carelessness in one of the fundamental operations.

As the multiplications and other computations involved more and more digits, errors were more frequent. With Horner's method, a small error may be cumulative; several students made such errors without noticing that a mistake had been made. On the other hand, since the graphic method makes a new computation at each step, a slight error may have no bearing on the final result. With the very long computations

needed for five or six decimal place accuracy, papers were noted in which a mistake at one step created the impression that the error was in the previous step, resulting in effort wasted in looking for an error in the wrong place.

In general it is hard to say that either method has any distinct advantage in the avoidance of errors. Careful checking of the work failed to verify the claim that errors are discovered more rapidly when using the graphic method than when using Horner's method.

No claim is made that absolutely conclusive evidence is yet available. Corroborating the results of the previous study, it may be stated with even greater certainty that if two or three decimal place accuracy is sufficient, a solution by successive graphs enables either the beginning or the advanced student to obtain the desired answer with less expenditure of time than Horner's method. Should accuracy to more than three decimal places be required, it is of importance to note that the graphic method is no longer the more efficient. For four places, the graphic method will require almost twenty per cent more time, and this percentage will be increased as greater accuracy is required. Neither method seems to be superior with respect to the effect of errors committed.

Attention is again called to a statement made in the previous report, that no claim is made that the graphic method gives the theory of Horner's method. Even if it is assumed that theoretical considerations are to be left for a more advanced course, it would seem to be of great importance to attempt to determine whether any appreciable portion of a class is likely to require considerable amounts of computation involving extreme accuracy before eliminating the study of Horner's method.

MATHEMATICIANS OF NEW YORK CITY TO HOLD LUNCHEON

The annual open luncheon meeting sponsored jointly by the Association of Mathematics Chairmen and the Association of Teachers of Mathematics of New York City will be held on Saturday, March 12, 1938, at 12:30 P.M., at the Essex House, 160 Central Park South, New York City.

The principal speaker will be Dr. Harlow Shapley, Director of the Harvard College Observatory. His topic, THE CURRENT EXPLORATIONS OF ATOMS AND GALAXIES, will be illustrated with lantern slides.

Tickets ($1.75 including gratuities) are obtainable by addressing Mr. Samuel H. Barkan, Benjamin Franklin High School, 309 East 108th St., New York City.

USE THE CORRIDOR IN TEACHING SCIENCE

By Warren L. Bartlett
Brookline High School, Brookline, Mass.

There is nothing new in the use of exhibits as visual aids in teaching, yet if one has a group of indirectly lighted, corridor cabinets in which to display his exhibits, he is indeed fortunate. When the building is constructed, these cabinets should be installed in the corridor walls. They should be about 40″ high, 35″ wide, and 16″ deep with movable glass shelves. The lighting effects in each cabinet may be controlled by a wall switch. Many cabinets of this moderate size are better than a few large ones, for they give an opportunity to develop many projects and to present a variety of ideas.

A museum with row on row of inanimate objects accurately labeled and scientifically arranged can be a total loss to a high-school pupil, despite its value to a research student. The average student is not particularly interested that the Golden Plover has the scientific name of *Pluvialis dominica dominica* and belongs to the family *Charadriidae*, but he is arrested by the statement that this small creature is the champion, non-stop flier among the birds. If its course is plotted on a map to be displayed with the mounted specimen of the bird, the whole effect is an added interest in birds.

Other unusual displays will attract students. A mineral case can be a prosaic thing, yet when those minerals are made to fluoresce upon the turn of a switch, a new world of color and interest is awakened. A glimpse of a coral reef can be had in a dimly lighted cabinet where tropical fish suspended by hairs sport about among corals and sea fans. Many students are interested in game laws and can be taught readily by seeing displayed mounted specimens of the game birds together with information on the length of the open season, the bag limit, or other pertinent data. If the teacher is blessed with a quantity of birds, there is no end to the valuable displays he can set up. Here are a few:

1. Habitat groups of birds of any given season with appropriate backgrounds and other effects
2. Extinct birds or those that are on the wane with emphasis on conservation
3. Birds that fly great distances and maps plotting their courses

4. Birds of a given genus or species to illustrate classification
5. Birds in a setting to illustrate protective coloration

A frame that holds lantern slides which fits the front of the cabinet and is lighted from behind is of great value. These slides can be changed as often as continued interest demands.

If the school boasts collections of shells, butterflies, corals, minerals, and birds, many attractive displays depicting such topics as color in nature, mimicry, economic value and ecology can be presented with profit.

Commercial displays showing the steps in the manufacturing process of various articles such as rubber and rayon can be used, but they lack the motivating power of an original idea conceived on the part of a pupil or teacher and carried out with materials made or collected by one's own hands.

One of the most valuable features of science displays is the opportunity to coördinate science with many other activities of the school. The Art Department is called upon for posters, transparencies, and backgrounds for habitat groups. The Printing class furnishes neat labels for mineral, fossil, or other displays. The Library coöperates with paper covers of recent scientific books. The Latin Department traces the etymology of the scientific names of plants and animals. The Stamp Club contributes a display depicting the history of science in stamps or one showing the fauna and flora of the world. There is opportunity for the Camera, Aero, Science and Radio Clubs to display the products of their handiwork.

In the field of Physics, mechanisms in motion attract a lot of attention. A model four-cycle gasoline engine is made to operate upon turning a switch. Its operation becomes more meaningful by a card that explains the action of the valves, spark and piston. In a similar manner a model airplane engine, large electric bell, and a moving picture machine perform for the interested boy or girl. At New Year's time the use of the electric eye is shown by having a "Happy New Year" sign light up when a beam of light is intercepted by a passing pupil. A display of properly labeled apparatus drawn from all fields of science serves to acquaint the pupil with those that he will use in subsequent courses. A lesson in density is taught by displaying cylinders of different kinds of wood and metal that all weigh the same.

The electromotive series and deliquescence suggest topics that the chemistry teacher could profitably illustrate.

There are endless ways by which an ingenious teacher with the help of his pupils may present scientific principles, beautiful concepts, or inspirational ideas through the use of corridor cabinets readily accessible to pupils as they pass from class to class. Pupils are keen to conceive the possibilities that can be presented and are skillful in arranging effective displays.

No one set-up should remain over a long period of time. The value in stimulating interest lies in their being changed frequently. The displays should be simple in design, demonstrating one point and that vividly. A pupil passing from class to class has not time to study an exhibit at length. To that end the labels should be large enough to attract attention, the lesson obvious, and the point of the display worth knowing.

It is convenient to have a storage cabinet built below that of the display in order to receive a used one that may be set up again another year or even later.

New schools are constantly being built. Let us not underestimate the value of built-in, corridor cabinets whose proper use can be productive of many profitable educational enterprises. The author has found during five years of experience with these cabinets that such displays are invaluable.

OUTDOOR RECREATION CONFERENCE

The fifth Outdoor Recreation Conference under the sponsorship of the Massachusetts State College will be held at Amherst March 10–13. The Nature Section will meet Saturday, March 12. Its theme will be Outdoor Leadership in Recreation-Conservation.

During the last three years nature recreation has developed more than a decade in advance of expectations. For example: 142 City Parks have activities in nature recreation. 101 Cities are maintaining 270 nature trails. New York, Indiana, Pittsburgh and Cincinnati are maintaining a nature guide service. Recreation Demonstration Projects are converting thousands of acres of submarginal land into great playgrounds and camping areas. Land zoning is bringing about wild life sanctuaries. Wild life Inventories, Fields of Nature Landscape, Youth Hostels and a hundred and one related organizations are being born. The recent development of Out-of-the-City Parks with attendant hiking trails, picnic centers, boating, fishing camping, etc. are phases of nature recreation. There is immediate need for cooperative planning. Our outdoor school rooms are here. There is also *urgent need for trained leadership and a progressive program.*

This conference offers a unique opportunity for all nature fans interested in conservation recreation projects to discuss the problems informally and under favorable circumstances. This promises to be a historic meeting in that it is the first time that all of those interested in this increasingly important public utility have been asked to come together.

LABORATORY TECHNIQUES TEST

By Harold G. McMullen
Wisconsin High School, Madison, Wis.

Directions

Chemists have found that certain practices result in more efficient and safer use of materials and a saving of time. Below is a list of some of these activities. Classify each of them by placing the letter or letters of the reasons for each activity on the line that follows the activity.

Reasons for the Practices

(a) Safety of experimenter.
(b) Safety of others in laboratory.
(c) Neatness and cleanliness.
(d) Saving of chemicals.
(e) Saving of apparatus.
(f) Saving of time.
(g) More efficient operation of apparatus.

Laboratory Practices

1. Wet filter paper before filtering........................
2. Make a smooth rounded right angle bend in glass tubing....
3. Pour powders or crystals on folded paper instead of directly into test tube.........................
4. Be sure thistle tube is below the liquid in a gas generating flask.......................................
5. Light the match before turning on the gas.............
6. Turn the flame of the Bunsen burner down to four inches below the level of the liquid being heated in glass........
7. Always support crucibles on pipe-stem triangle..........
8. Stand funnel, mouth downward, on the desk............
9. Rotate bottle when pouring powder from it.............
10. Place wire gauze beneath glassware that is to be heated...
11. Slide solids in test tube while in an oblique position......
12. Move flame when heating glassware until glassware becomes hot.......................................
13. Flush sink with water after throwing away acid..........
14. Replace reagent bottles immediately after using..........
15. Fire polish all glass tubing.........................
16. Smell gases by fanning a small amount of the gas toward the nose......................................
17. Point test tube away from yourself and others when heating..

18. Wet glass tubing before putting through rubber stopper. .
19. Keep a steady flow of gas from generator to prevent "sucking back" of liquid in delivery tube. . . . .
20. Use flame spreader on burner when bending glass. . . . .
21. Wash all glassware immediately after using. . . . .
22. Always pour concentrated acid into water slowly with constant stirring. . . . .
23. Hold stoppers from reagent bottles in fingers when obtaining reagent, and replace stopper immediately. . . . .
24. Remove flame when evaporating to dryness just before all the solution has evaporated. . . . .
25. Use stirring rod to apply a drop at a time, either acid or base, to litmus paper. . . . .
26. Keep liquid below the level of filter paper when filtering. .
27. Adjust air supply to burner after lighting. . . . .
28. Do not throw solid material into the sink. . . . .
29. Do not taste anything unless told to do so by the instructor . . . .
30. Flood clothing or skin with water and follow with baking soda when acid is spilled accidentally. . . . .
31. Add glass beads when boiling strong alkali solutions. . . . . .
32. Plan apparatus so that none of it needs to be supported on books, match boxes, et cetera. . . . .
33. Always use rubber stoppers with holes that fit tightly around glass tubing. . . . .
34. Use only the amounts of reagents prescribed in the experiment. . . . .
35. Put away all apparatus not being used in the experiment . . . .
36. Keep desk top clear of burned matches, spilled liquids, fragments of salts, et cetera. . . . .
37. Shut off gas and water when they are not being used. . . . .
38. Use fingers to judge pressure being applied to clamp when it is being used on glassware. . . . .
39. Put all used solids in waste jars. . . . .
40. Wash table tops after each experiment. . . . .
41. When heating solids in test tube, hold tube in a horizontal position, the mouth slightly higher than the closed end. . .
42. Be sure glass vessels are dry on the outside before heating . . . .
43. Use a glass stirring rod when pouring from a beaker, in order to direct the flow of the liquid. . . . .

44. When filtering, allow the stem of the funnel to come in contact with the side of the beaker into which the filtrate is running..
45. Cool hot glassware slowly..............................
46. Let the blue cone part of the burner flame come in contact with the wire gauze when heating..................
47. Report to the instructor all injuries as soon as they occur..
48. Work glass tubing through stoppers with a rotary motion, and with the fingers near the stopper..................
49. Remove delivery tube from water as soon as you cease applying heat to generator.............................
50. Use sand on oil or gasoline fires........................

AN OPTICAL ILLUSTRATION OF CONIC SECTIONS

By Galen Wood Ewing
Chicago, Illinois

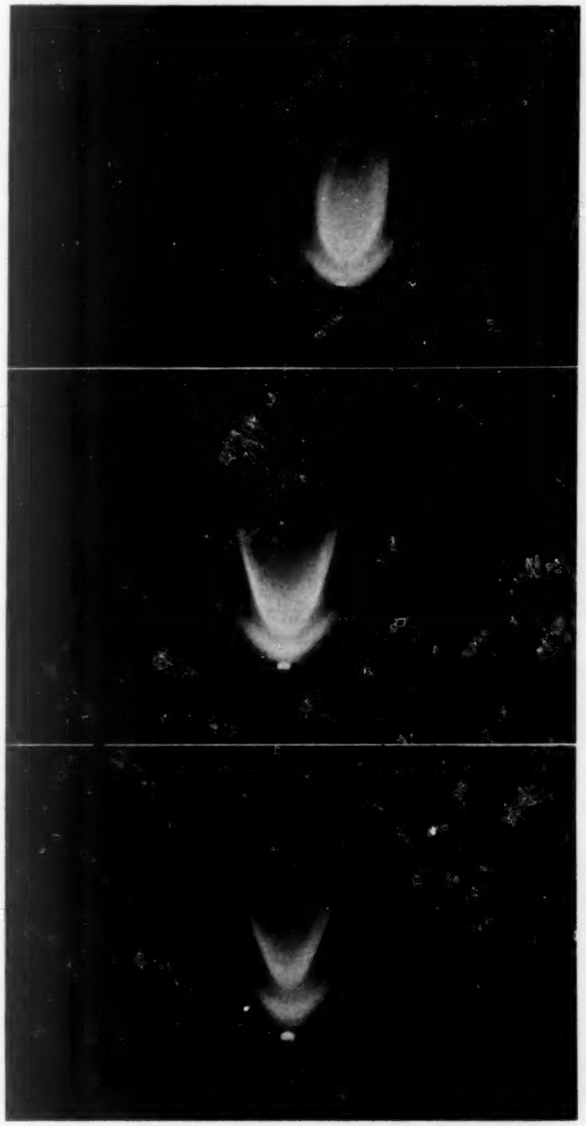
To many students pure mathematics is so unreal that any practical aid which the teacher can bring to the study is likely to prove of much assistance, especially to the unimaginative student. In the teaching of conic sections such aid is often rendered by the wooden cone sawn into sections along different planes. In some ways an illustration with a common flashlight is more useful as well as less expensive.

It can easily be shown to a class that the divergent beam from an ordinary flashlight is in the form of a cone whose apex is approximately at the luminous filament. By casting the light upon the wall of the classroom or upon a piece of cardboard and turning the lamp at various angles, the cone can be intersected by a plane in any desired way.

By holding the lamp with its axis perpendicular to the wall or card a circle of light will be seen; by gradually altering the angle, the light will progressively take the form of an ellipse, a parabola and a hyperbola. Three forms are shown in the photographs.

It is recommended that a flashlight of the inexpensive type with a lens be used rather than a focusing lamp. A little advance practice will make apparent the best part of the room in which to show this illustration; it may show to advantage on a blackboard, on which the pattern can be traced with chalk. A piece

of white cardboard has the advantage of manipulation, whereby the actual sectioning of the cone can be done before the eyes of the students.



Top: Fig. 1. Ellipse
Center: Fig. 2. Parabola
Bottom: Fig. 3. Hyperbola

A CLASS PROJECT IN COMPARATIVE ANATOMY

By John P. Wessel
Wright City Junior College, Chicago, Illinois

The original purpose of this project was the development of a fuller appreciation of the enormous depth and breadth of the science of Comparative Vertebrate Anatomy. However, other values emerged as the project progressed. These values are listed in the summary.

The project involved the preparation of a library research thesis for which the information was obtained from books, periodicals, and bulletins. The libraries used were the Crerar Library, Chicago, Illinois; the Biology and Billings Libraries, University of Chicago; and the library at Wright City Junior College, Chicago, Illinois.

The class was divided into three groups. The pre-dental students constituted one; the pre-medical students another; and the third constituted students majoring in zoology, English, mathematics, etc. For convenience we will refer to this last group as the L. and A. group.

Each pre-dental student was assigned the subject of the origin, development, and comparative anatomy of vertebrate teeth. The study was to be based on an extensive review of the available literature. Through the courtesy of the department of English every student was supplied with a set of directions concerning the mechanics of organization and technique of annotation to be used in the preparation of the paper.

Each pre-medical student devoted himself to the study of the origin, development, and comparative anatomy of one of the various organs or systems. Some of the topics which students preferred most widely were, the skull, the brain, the aortic arches, the heart, the venous system, the vertebral column, the urogenital system, the appendicular skeleton, and the respiratory system

The L. and A. student chose for his thesis subject the origin and evolution of any one of the vertebrate groups. The aim in this study was to emphasize three important aspects: primitive forms (hypothetical or actual) that occupy a position on the direct line of avian and mammalian ancestry; evidences of convergent evolution; and evidences of divergent evolution.

Toward the end of the semester, when the members of the

class had become saturated with the many facts, concepts, and trends of comparative anatomy, we attempted to coordinate and integrate these materials with the aid of the projects. The individual student projects now took the form of a class project. Seven of the L. and A. students, who had shown superior ability in class work, were chosen to present their theses orally to the entire class. To insure a high degree of familiarity with the subject matter of their theses, I did not permit them to use notes.

The subjects of the L. and A. theses are of a general nature and cover large units of the field; whereas the subjects of the pre-dental and pre-medical theses are very narrow, highly specialized units. However, any study of the origin and evolution of a group of vertebrates is based largely on a study of organs and systems. The speakers were fully aware that they were speaking to an audience of specialists on organs and systems. A mistake or deficiency in presentation would be immediately recognized by some member of the audience. An impersonal, objective criticism followed. The speakers were thus motivated toward being well prepared, and as a result the class usually received an excellent summary of the evidences for the origin and evolution of the various vertebrate groups.

In this way the various materials gathered from the laboratory, lectures, reading assignments, and library research theses were coordinated and integrated by the students themselves through collective student effort.

The titles of the student lectures and the order in which they were delivered are as follows:

1. The Origin of the Chordates and the Evolution of the Pre-Chordates.
2. The Origin of the Vertebrates and the Evolution of the Fishes.
3. The Origin and Evolution of the Amphibia.
4. The Origin and Evolution of the Reptiles.
5. The Origin and Evolution of the Birds.
6. The Origin and Evolution of the Mammals, excluding the Primates.
7. The Origin and Evolution of the Primates, including Modern Man.

In conclusion I believe that the following values were derived from such a class project:

1. The student obtained a fuller appreciation of the enormous

depth and breadth of the science of Comparative Vertebrate Anatomy. By making an intensive and somewhat exhaustive study of one phase of the course, he developed a greater degree of respect for the science of Comparative Anatomy and thereby obtained a richer and more mature concept of science.

2. The students obtained a more comprehensive point of view through coordinating and integrating their knowledge. This led to a more complete understanding of the ancestry of man, of the orderly progress of the organic world; and of important trends in Comparative Anatomy.

3. It provided the superior students an excellent opportunity for self-expression.

4. The mechanics and technique involved in the preparation of the theses and the delivering of the lectures provides an integration between the work of the departments of biology and English.

5. The geology and paleontology involved in the studies offer an opportunity for the integration of work in the Biological Sciences with that of the Physical Sciences.

6. Any study involving the progress of a science necessitates a consideration of historical, sociological, and philosophical factors, and thus the Biological Sciences meet on a common ground with the Humanities and the Social Sciences.

MEASURING TO A MILLIONTH OF AN INCH WITH A POCKET HANDKERCHIEF

By George Woolsey
Valencia High School, Placentia, California

Several years ago I attended a lecture given by Dr. Millikan in which he discussed relations between the wave and corpuscular theories of light. During the course of the lecture he demonstrated the formation of diffraction patterns by asking the members of the audience to look through their pocket handkerchiefs at two small lights on the speaker's platform, one red and the other blue. He called attention to the fact that the red images are farther apart than the blue ones, thus giving a very simple demonstration that the wave length of red light is greater than that of blue light.

It occurred to me that this experiment might easily be

adapted to measure the wave length of light in a way which would be suitable for use in high school physics classes. Since then several classes have made use of the experiment for this purpose. The method of using the experiment quantitatively is this:

Bright lights are placed behind two small openings a few centimeters apart. These openings are covered with glass of the color of which the wave length is to be measured. When the student looks through his handkerchief at these lights at a fairly close distance the pattern that he sees consists of two sets of nine images.

. . .   . . .

. . .   . . .

. . .   . . .

The student is instructed to back up until the two inner rows coincide, thus making the distance between adjacent images equal to one half the distance between the apertures. The distance between apertures and the distance from the openings to the point of observation are measured. The number of threads per inch are next determined by means of a linen tester magnifier. With this data the student is ready to compute the wave length of the light by means of the diffraction formula.

The diffraction formula adapted for use in this experiment is

$$\lambda = \frac{d}{2nl}$$

where λ = wave length in inches.
d = distance between apertures.
l = distance from apertures to point of observation (same units as d)
n = number of threads per inch.

Representative data obtained by means of this experiment indicate the degree of accuracy which is likely to be attained.

Light	d cm	l cm	n	λ (calcd) in. $\times 10^{-6}$	λ in. $\times 10^{-6}$	% difference
Clear tungsten filament	4.10	876	100	23.4	22.8	2.6
Red	1.67	322	100	25.9	25.6	1.2
Blue	1.67	346*	100	16.1	18.5	13.0

* Due to poor intensity of the blue light the two inner rows were not made to coincide but were made as far apart as were the other rows. For this arrangement the formula becomes $\lambda = d/3nl$.

TEACHING VALENCE BY MEANS OF THE ELECTRONIC THEORY

By Saylor C. Cubbage
Woodrow Wilson High School, Washington, D. C.

An understanding of the concept of valence and its applications is essential to progress in the mastery of chemistry and all teachers of the subject realize that it is needed early in the elementary course. The beginning student has difficulty in writing correctly the formulas of compounds. It is obvious that one can never write formulas correctly until the valences of a considerable number of elements and radicals are learned. After the valences of some of each type are learned, the valences of others can be deduced from the formulas of compounds already learned. Valence may be defined tentatively as the measure of the capacity of an atom or radical to hold other atoms and radicals in combination. The fact that many elements have several valences presents a puzzle to the beginning student. The explanation of valence from the standpoint of electronic exchange gives a reasonable basis for the existence of multiple valence and would seem to clarify these apparent inconsistencies.

The atom with its full quota of electrons, i.e., the neutral atom, has a valence of zero. Only when there is a loss or gain of electrons does the atom have a valence and become capable of chemical activity. I believe the teaching of valence by means of the electronic concept is the most practicable method of making the student understand why atoms have affinity for one another, or have valence, and why some elements have more than one valence. A knowledge of the underlying basis of valence shows the pupil why atoms combine at all and why they combine in the ratios in which they do and not in a chance sort of way. The pupil soon notices by examining chemical formulas that in one compound one kind of atom combines with one of another kind while in others one or two atoms of one kind combine with two or three or four of one or more kinds. Why all this variation? Is it all according to chance or is there some law governing such combinations?

As a basis for the teaching of the electronic conception of valence it is necessary to set forth the idea that all matter, ac-

cording to present belief, is electrical in nature. Glasstone[1] states that "the first definite ideas leading up to the modern electronic theory must be attributed to Kossel (1916), and G. N. Lewis (1916), independently." The units of structure of the atom are the proton, the unit of positive electricity, and the electron, the unit of negative electricity. In any neutral atom there is an equivalent number of protons and electrons. The theory of the dynamic atom which has grown out of the work of J. J. Thomson, Moseley, Rutherford, Bohr and others is very applicable in presenting the electronic theory of valence. This states that the mass of the atom is concentrated in a positively charged center, or nucleus, surrounded by a definite number of electrons, of almost negligible mass, revolving at high velocities in orbits at definite distances from the nucleus. The nucleus contains all the protons along with a part of the required number of electrons. The net charge, the difference between the number of protons and electrons in the nucleus, is always positive. This value is the atomic number and is also equal to the number of orbital electrons in the atom. The number of electrons in the outside orbit is a controlling factor in determining the chemical properties of the atom.

There is a definite arrangement of these extra-nuclear electrons in orbits in certain satisfied or stable arrangements as far as this can be attained. Every atom tends to reach a stable condition by completing its outside orbit The first orbit is complete with two electrons Any outside orbit which is beyond the first tends to reach a complete arrangement of eight electrons. The insistence of the atom to attain a completed pair or octet in its outermost orbit and develop a symmetry characterized by the inert gas atoms accounts for its chemical activity. This characteristic of the atom is the basis of chemical activity and in turn is the basis for chemical union. Any element which immediately follows an inert gas in the periodic arrangement easily loses an electron and forms a positive univalent ion while one that immediately precedes an inert gas easily gains an electron and forms a negative univalent ion. An atom that follows two places after an inert gas in like manner forms a positive bivalent ion and one which precedes the inert gas by two places forms a negative bivalent ion, etc. This idea may be illustrated by the following table given by Sidgwick.[2]

[1] Glasstone, Samuel. *Recent Advancements in Physical Chemistry*, Churchill, London. 1933.
[2] Sidgwick, N. V., "Valency," *Encyclopedia Britannica*. 1937.

Element	O	F	Ne	Na	Mg	Al
At. No.	8	9	10	11	12	13
Ion	O^{-}	F^{-}	Ne	Na^{+}	Mg^{++}	Al^{+++}
Electrons in ion	10	10	10	10	10	10

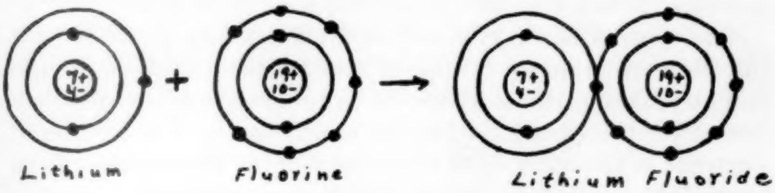
Sidgwick declares that the guiding principle in the establishment of a satisfied arrangement in the atom is the stability of the 10(2+8) electrons.

Atoms unite chemically when there is a possibility of rearrangement of their electronic systems so as to provide a more stable condition in their respective outer orbits. If an atom has a very small number of electrons in its external orbit, or valence ring, it is easier to lose these electrons and revert to a stable arrangement of eight than it is to receive enough electrons to complete the octet. If the atom has a larger number of electrons in the valence ring, say five to seven, it is easier to gain electrons to complete the octet than to lose all these to reach a stable condition. Atoms which lie in the center of the periodic table can just as easily gain electrons to complete the octet as to lose them and revert back to a stable configuration. The fact that there is a regular recurrence of a characteristic set of properties as one advances through a certain number of steps in the periodic table suggests that the number of electrons acquired forms a new and stable group. Sodium and potassium have similar properties because the eight additional electrons in the latter are grouped in such a way as to provide the same number in the outer orbit of each atom.

The atoms of the elements termed the inert gases have little or no tendency to react with other atoms. The stability of the electronic configurations in the atoms of these gases is already so well established as not to permit any improvement by interaction with other atoms. The outer orbits of these are complete. Their valence is considered zero. There is no tendency on their part to gain or lose electrons. By gaining or losing electrons they would be departing from their established stable configurations. Thus, there is little possibility of these atoms combining with each other or with other atoms.

We may more broadly define the valence of an element as the number of electrons given up or received in order to reach a stable configuration. Chemical union takes place when atoms desirous of giving up electrons come in close proximity with

atoms desirous of gaining electrons and vice versa. This principle may be illustrated by the combination of lithium and fluorine, whose atomic numbers are three and nine respectively, to form lithium fluoride.



The lithium atom in losing its lone valence electron reverts to a stable pair while the fluorine atom in receiving the electron given up by the lithium atom completes its ring of eight. The lithium atom has become positively charged because it possesses one more proton than electrons in its structure. On the other hand, the fluorine atom is negatively charged because it possesses one more electron than protons. The two ions are drawn together in chemical combination by the force of electrostatic attraction because of their unlikeness of charge. The valences of the lithium and fluorine are positive and negative respectively. Elements that tend to lose electrons exhibit positive valence and those that tend to gain electrons exhibit negative valence.

Atoms which have one electron to lose from the valence ring easily combine with atoms which are eager to gain one electron; those eager to lose two electrons combine with others which are in need of two electrons to complete their valence orbits, etc. It may be said that atoms equally spaced on opposite sides of inert gases in the periodic table easily combine to form molecules.

The great majority of our ninety-two elements have more than one valence; in a few cases there is a rather wide variation. As a rule the alkalies and alkaline earths have no variation in valence. The idea of positive and negative valence has been mentioned previously in this paper. Any element may be said to possess both positive and negative valence. Abegg's rule states that the sum of the positive and negative valences of an atom is eight. For example, sodium whose positive valence is one would have a negative valence of seven, even though it may not exercise the latter valence. Oxygen has a negative valence of two and a positive valence of six. The number of

elements with a greater variation of valence than is permitted by the idea of positive and negative valence is quite large. The majority of these lie in or near the transition groups of the periodic table. The statement of the law of multiple proportions implies a variability of valence in elements.

The most satisfactory theoretical explanation at present for the wide variation in valence of some elements lies in the apparent ability of these elements to progressively release electrons from the second level to the valence orbit. The number of electrons in the outer orbit is the measure of the valence of the atom. If by any means electrons from the second level are made to pass to the valence group to increase its number the valence of the atom will be likewise increased. It is a recognized fact that iron has positive valences of two and three. The atomic number of iron is 26. The electrons are distributed in the successive orbits according to the following groupings: 2, 8, 14, 2; the two electrons in the outer ring accounting for the valence of two. In order for the atom to have a valence of three, one of the electrons in the second level must move out into the valence group or in some way make itself available for valence purposes once the two original valence electrons have been released in ionization. In the reaction in which the iron atom is oxidized from a valence of two to three one electron from the incomplete and unstable second level moves into the valence ring giving the following electronic distribution: 2, 8, 13, 3. Manganese has six known positive valences. The atomic number is 25. It may be assumed that the various electron distributions are as follows making possible the multiplicity of valences:

2, 8, 13, 2:	————	valence of 2
2, 8, 12, 3:	————	" " 3
2, 8, 11, 4:	————	" " 4
2, 8, 10, 5:	————	" " 5
2, 8, 9, 6:	————	" " 6
2, 8, 8, 7:	————	" " 7

In the latter electron arrangement in the table there is represented the stable arrangement of argon in the portion below the valence shell. The apparent ease of mobility of electrons from the second level to the valence orbit in the case of some elements in all likelihood explains their variable valence. The explanation of valence on the basis of electronic exchange gives a sense of order to the question of variable valence and removes from it the specter of confusion and apparent incon-

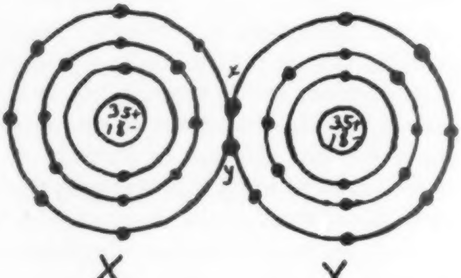
sistency. Many of the cases of variable valence similar to those cited above are found in those atoms whose next to the outer orbit is incomplete and consequently unstable. The maximum valence of manganese is seven. Just suppose that one more electron moved from the second level to the valence orbit. In that case the outer orbit would reach the rare gas configuration with a completed octet and would have a zero valence. But in order to do this and fulfill this unwarranted assumption it would be necessary to destroy the stable condition of the second level of the manganese atom which evidently holds eight electrons when the atom has a valence of seven. One would not expect this to happen.

In the transition elements and a few more the orbit next to the valence group does not hold the stable numbers of 2, 8, or 18 but some intermediate number between 8 and 18. Such an incomplete group does not hold its electrons very securely and may be persuaded to release some of them to the valence group, permitting a multiplicity of valence. But in the majority of cases where there are either eight or eighteen electrons in the second level the atom does not vary in valence. However there are certain cases and conditions under which this does not appear to be true. At any rate we may say that the stability of the under layers is certainly a determining factor as to whether or not the atom is characterized by variable valence. There is a variation in valence in copper and gold, each of which has eighteen electrons in the second level. Sidgwick[2] states that "the eighteen group, though it is normally very stable, is less so when the positive charge on the nucleus is barely sufficient to neutralize it, or in other words when its electrons are moving in a weak electric field." In the atoms of copper and gold each of which normally has one electron in its valence orbit it can be seen that there is present in the nucleus only one more proton than is necessary to neutralize the electrons in the orbits of either of these atoms up to and not including the valence orbit. Thus, the nucleus is little more than able to neutralize all of the electrons below the valence level. Sidgwick comments further by saying "Hence, in copper one, and in gold two, of these eighteen electrons can be detached from the group," making possible the bivalent cupric ion and the trivalent auric ion, leaving seventeen and sixteen electrons respectively in the second level. One might expect silver to act in the same way and exhibit a variable valence but for some undetermined

reason it does not act in this way. In the atoms of zinc, cadmium, and mercury which follow copper, silver, and gold, respectively, in the periodic table one does not find variable valence. These atoms having a valence of two, of course, have two electrons in the valence ring, i.e., beyond the second level which contains eighteen. The increased relative nuclear charge with respect to the electrons below the valence orbit holds the eighteen of the second level sufficiently firmly to prevent any of them from passing to the valence level and permitting variability of valence. In the atoms comprising the first two periods of the periodic table the electrons below the valence levels represent configurations too stable to be shaken by ordinary chemical means and made to yield electrons from the second level for valence purposes.

The atoms of hydrogen, oxygen, nitrogen, and chlorine unite with atoms of their own kind to form diatomic molecules. We write the formulas for these gases accordingly. In the combination of two like atoms to form a molecule a mutual satisfaction or stable arrangement develops with the completion of the outer orbit of each atom without the actual transference of an electron from one atom to another. The electrons maintain their original relative positions but are shared in common between the two atoms. The linkage in such cases is the shared pair of electrons and is spoken of as the covalent bond.

Chlorine may be used to illustrate the principle:



The Chlorine Molecule

In the covalent link the first atom shares the electron furnished by the second atom and the second atom shares the electron furnished by the first. In the illustration the *y* electron from the *Y* atom may be said to complete the octet of *X*, in like

manner the x electron from the X atom completes the octet of Y. The electrons in this shared pair cannot be considered to be stationary but continue to revolve around their own nuclei. This type of linkage is distinct from the polar bond since there is no actual transfer of an electron from one atom to the other causing each to be electrically charged. Ionization does not occur in this type of linkage. The atoms are held together in this arrangement merely by the deep-seated tendency of each atom to hold an octet (a pair in the case of the hydrogen molecule) in its outer orbit. Oxygen with a valence of two will have two pairs of shared electrons on formation of the molecule; hydrogen one shared pair; and nitrogen three shared pairs.

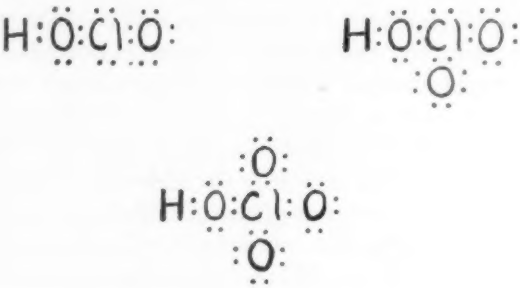
Chapin[3] suggests that chlorine and its related elements are able to give up part or all of the seven electrons in the valence orbit and consequently exhibit various values of positive valence. He suggests that in $HClO$ the chlorine acts with a positive valence of one and has given one electron to the oxygen atom, the other being furnished by the hydrogen atom with which it is combined. In $HClO_2$ it has transferred three of its electrons to the oxygen atoms; in $HClO^3$ five electrons; and in $HClO_4$ it has transferred seven electrons to the oxygens. The valence considerations in such compounds perhaps can be explained in a better way by assuming the presence of shared electron bonds and another type of bond called the coordinate bond, rather than the actual loss of electrons from the chlorine atom. In the coordinate bond a shared pair is involved but it is furnished by one and the same atom. In $HOCl$ there is one shared or covalent bond and one polar bond, permitting ionization. The bond between the hydrogen and oxygen is polar but the one between the oxygen and chlorine is covalent.

$$H:\underset{..}{\ddot{O}}:\underset{..}{\ddot{Cl}}:$$

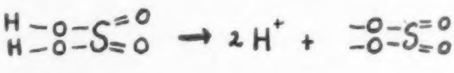
In $HOClO$, $HOClO_2$, and $HOClO_3$ there are one, two, and three oxygen atoms held respectively by the chlorine by coordinate bonds. They may be represented as shown on the following page. In solution these compounds are capable of ionizing at the polar bond but not at the covalent or coordinate bonds Each ionizes to yield a hydrogen ion and the radical characteristic of the acid. The radical remains intact. The same principle applies to the salts of these acids.

[3] Chapin, Wm. M., *Second Year College Chemistry*, John Wiley and Sons. New York. 1933.

Students of elementary chemistry soon learn the relation between valence and atomic structure if they are assigned the task of determining the valence of not too complicated atoms from the electronic arrangement. They can derive the valence provided they have the information concerning the number of electrons to be placed in the respective orbits. Given the atomic numbers of elements whose valence they did not know, I have seen students deduce their valences on tests from their knowledge of electronic arrangements.



A useful way to present the method of determining the valence of radicals is to write out the structural formula for a compound containing a certain radical and erase away the symbol for the atom or atoms attached to the radical leaving the valence bonds protruding. The number of bonds dangling outward is equal to the valence of the radical.



In the act of erasing away the two hydrogens from the formula one is merely picturing what takes place in ionization.

The capacity of an electron to give up or receive electrons has a direct bearing on the value of the equivalent weight of the element. If the atom is capable of giving up or receiving one electron its equivalent weight is the same as its atomic weight. Briefly said, the number of equivalents in the atomic weight of the element is numerically equal to its valence.

In the light of the basic considerations of the electronic conception of valence we may define valence in terms of the number of electrons gained or lost by an atom or the number of pairs of electrons shared by the atom in order to reach a stable condition. The various types of linkages which are present be-

tween atoms are well accounted for by means of the electronic theory on the basis of a rearrangement of the valence electrons. The cause of this rearrangement is the tendency on the part of atoms to establish a more stable arrangement of their electrons.

GENERAL SCIENCE DEMONSTRATIONS

By Leroy D. Johnson
Storer College, Harper's Ferry, West Virginia

Since pupil activity is a feature of our educational system, the writer offers the two demonstrations presented as practical procedures in teaching the movements of the earth and moon, to high school general science students.

Though these presentations have their limitations and the ideas may not be entirely new it has been found that these visual and imaginative procedures have aided students considerably in understanding the problems presented.

Demonstration I

Revolution and Rotation

The teacher or one of the students in the class makes a circle about eight feet in diameter on the floor with a piece of chalk or string. This represents the orbit or path of the earth.

The teacher then selects two students and designates one to represent the earth and the other the sun.

Two cardboards of convenient size may be made and labeled —sun—earth—respectively (preferably by the students).

The student who is to represent the sun is instructed to move into the center of the circle, with the card labeled sun.

With placard labeled earth in his hand the other student is told to walk around the path outlined by chalk or string. The class may then be told this movement represents revolution.

Without moving around the circle but remaining in a spot on the circle (which may be marked) the student representing the earth is asked to pivot completely and slowly.

This motion represents rotation. The period of this turn can be said to represent twenty-four hours or one day. When the individual is facing the student representing the sun this will represent day but after having made a half turn or pivot when said student can no longer see student representing sun this would represent night (midnight).

It must be pointed out that both revolution and rotation take place at the same time.

To represent both motions the student representing the earth is then asked to pivot and move around the circle at the same time remaining in the path or chalked circle representing the earth's orbit.

It requires some balance and poise to turn and at the same time remain in the constructed path, but to the onlooking students the outcome of these motions and notations injected have been, on the whole, quite desirable.

Demonstration II

Path of the Moon

The student representing the sun stands at the center of the circle (drawn as in Demonstration I). Since the object of this experiment is only to show how the moon moves it is advisable to omit the rotation of the earth. At the end of the experiment this added motion might be shown to show the complexity of the astronomer's job in studying the heavenly bodies.

The student representing the earth will walk in the constructed circle around the student representing the sun and the student representing the moon at the same time will move around the student representing the earth.

During these movements opportunity is given to point out how the moon croses and recrosses the earth's path while going in a path about the earth and also around the sun.

It is to be noted that the actual size of the bodies involved is not representable by this method but the visual and imaginative procedure is helpful to the average pupil or student.

WESTON TEST EQUIPMENT FOR INDUSTRY, SCHOOL AND LABORATORY

This new bulletin describing multi-range test equipment of high flexibility, has just been issued by the Weston Electrical Instrument Corporation, Newark, N. J. This bulletin illustrates six standard models of the multi-range test instruments, and contains complete descriptions of their uses, ranges, electrical specifications, dimensions and prices.

Among the instruments discussed are the Type 1 analyzer (volt-ohm-milliammeter), which measures a.c. and d.c. voltage, direct current and resistance over a total of 33 ranges, all contained in this one instrument and also the multi-range ohmmeter, for resistance measurements from 1 ohm to 300 megohms on six scale ranges. Other instruments discussed are the capacity meter, the volt-ohmmeter, the vacuum tube voltmeter and the test oscillator.

THE RADIO PROGRAM AS AN AID IN EDUCATION*

By Louis A. Astell
University High School, Urbana, Illinois

From the orator's stand on an Athenian hill-top, as from a throne, Pericles made possible the Golden Age of Athens. That was almost 2000 years ago. So great was the influence of Pericles that an old Greek philosopher was led to say:

"A democracy can extend only as far as the sound of one man's voice."

Today, by way of the radio, any man's voice may be heard in territories farthest from our shores. The educational and commercial broadcasting stations give to our modern democracy potential values that far exceed the ancient speaker's stand. Indeed, these stations represent educational opportunities for another Golden Age.

Obviously, the radio program cannot replace the textbook or the teacher any more than it can replace any type of visual aid. Teachers most effectively using these aids correlate the various types with each other and with the subject matter. Since each aid has its own inherent values, one may not be used as a substitute for another nor to the exclusion of all others. Through approaches by various aids to a given subject, then, we come to have more complete conceptions of that subject.

If we consider the importance of the radio to education in general there is evidence of a significant influence. A recent report, prepared jointly by the United States Commissioner of Education and the Director of the Federal Radio Project, showed that for a period of some seventeen months, a total of 1260 educational broadcasts was given. This number of broadcasts, it has been pointed out, represents a record unparalleled in radio education.[1]

The extent to which radio programs are used in secondary schools is a vital question. Concerning this problem, the United States Office of Education, in the 1936 survey,[2] has shown the following pertinent facts, among many others:

---

* Presented before the Annual Convention of the National Association of Educational Broadcasters at the University of Illinois, September 13, 1937.

[1] Kelly, Lamar: "Say Air Education Has Big Following," *New York Times*, July 11, 1937.

[2] Dent, Ellsworth C. *The Audio-Visual Handbook*, Chicago, Illinois: The Society for Visual Instruction, 327 S. LaSalle Street, 1937. 181 pp. Page 126.

(1) As the enrollment of the junior high school increased, the percentage of such schools using radio programs *often* tended to be lower than for intermediate schools of the same size.

(2) The senior high schools, generally speaking, used radio programs *often* in a smaller percentage of cases than did the junior high schools. In fact, the percentage of senior high schools using radio programs *often* varied little from the percentages for the primary grades. Between 10 and 20% of the senior high schools, to state the case in still another way, use radio programs *often*. The percentage of senior high schools using radio programs beyond the limitations of the term *often* is not revealed, nor is information available on the number of such schools making a maximum use of radio programs in the most effective manner. Again, information is meager as to the specific subjects best suited to enrichment by radio.

With reference to the senior high schools, one of the most distressing problems is found in these facts:

The greatest number of high schools have an enrollment of much less than 750. Yet, here in these smaller schools, with teachers more generally recruited from the inexperienced group; with individual teachers usually required to present a greater variety of subjects than teachers in the larger high schools; with teachers of the smaller high schools commonly hampered by a lack of library, laboratory, and other facilities; with all these factors bearing upon the learning situation for the child, the radio is used less in the smaller than in the larger high schools. In the face of these facts, all agencies concerned with educational broadcasts must be intensely interested in the development of intelligent listeners at the secondary level; at a level where results are more obvious because so little has been accomplished up to this time.

Since the students in 80% of the high schools of our country are in an educational atmosphere where the dynamic values of the radio have no appreciable influence, we may well consider two major phases of the radio program as an aid in education. The first of these phases has to do with the functions of the radio, and the second, with a few of the more important problems and possible solutions. I shall be concerned largely with the functions and problems as I have observed and interpreted them at the secondary level.

For the purpose of presenting the importance of the radio as seen by educators, I have grouped the various functions in

the following five categories: Those functions concerned with (1) general educational trends; (2) unification of local or other school units; (3) teacher activities and work; (4) the all-important student product; and, (5) with adult relationships. Both as regards educational trends and unification of school units, the radio may serve as an important directing force. The radio, as Darrow has said, may serve as *The Assistant Teacher* in supplementing the work of the regular teacher; that is, in giving variety to classroom procedure; in making it possible for the teacher to have time to study the pupils in action; and, in contributing toward professional growth. One of the most important ways in which the radio may serve at this point is through a series of broadcasts designed for local "in-service" teacher training. The local "in-service" meetings could be improved immeasurably by broadcasting lectures that are ordinarily included in the county and district meetings and are not dependent on vision for an adequate understanding. Thus the county, sectional, and other meetings might be shortened and improved with less expense to the teachers, who in many cases continue to be an under-paid group. Whole series of programs on a common theme for teacher audiences might be handled in the same way. I believe that a carefully developed "in-service" series of after-school programs would represent a service resulting in greatly added prestige for educational broadcasting stations.

Under the "student product" or fourth category, the radio serves such functions as that of bringing first-hand information, including realities, to the student for his reaction; of integral enrichment for broadened and humanitarian outlooks; of interests, new and previously developed, resulting in the all important self-activity along desirable lines; of skillful note-taking; of intelligent listening responses; and, of awakened interests in better speech. As in the case of the various visual aids, the radio for the student represents another approach to the subjects for which, through an unvaried type of presentation, all interest has been lost. An average boy, for example, may see no real need for understanding the use of adverbial clauses and prepositional phrases until he has an opportunity to work with a group in preparing a radio script concerning his hobby. I am thinking now of one of my former students. This boy had made a portable sound system which included a double turn-table for records and a mixing panel. He was little concerned about his English until an opportunity presented itself for him to

bring his equipment some 75 miles for a demonstration on the "Ham Forum" and the "Illinois Junior Academy of Science" programs over WILL. Then, as Kilpatrick might say, the boy learned English when he needed it, as much as he needed and because he needed it. In a like manner, valuable correlations between various subjects offered in the secondary schools may be made in relatively easy ways.

The creation of public interest in education, as a factor of the fifth category outlined above, is likely to be a by-product of increased proportions when the radio is serving adequately the various educational functions to which it may be put. I recognize with Abbot that "The broadcasting of educational programs to the school is seriously handicapped at the present time by lack of cooperation between the receivers and broadcasters."[3] I do not believe, however, that this "lack of cooperation" is as unintentional as it is unsupported by the constituencies on which the educator must depend. The lag characteristic of public acceptance of "innovations," as Doctor Wilbur Beauchamp would term the radio in education, is as inevitable in a democracy as is the time element required to develop teachers to use such innovations effectively. Undue forcing of the issue on either side may impede the momentum of the cause.

Of theimportant problems one, quite logically, is that of equipment. Under the auspices of the American Council of Education, Koon and Noble in 1936 found that there was one central sound system for every 332 schools and one radio for every 24 schools involved in the survey. Teacher training schools equipped with either central sound systems or with efficient radios are not common in spite of the fact that in 1935, according to Umstattd, "no secondary school in America was considered fully equipped unless it had at least one receiving set,"[4] and in spite of the fact that in more than a thousand secondary schools, "instruction by radio is a well-established part of the instructional program."

Technical descriptions of desirable radio and public address equipment have been made by such authorities as Abbot,[5] and Tyson.[6] To me, a dependable radio permanently installed

[3] Abbot, Waldo. *Handbook of Radio Broadcasting*, New York: McGraw-Hill, 1937, xi+424. Page 254.

[4] Umstattd, J. G. *Secondary School Teaching*, Boston, Ginn and Co., 1937, x+459. Page 319.

[5] Abbot, Waldo. loc. cit., pp. 258–272.

[6] Tyson, Levering and others. *Present and Impending Applications to Education of Radio and Allied Arts*, Chicgo, Illinois: University of Chicago Press, 1936, vii+88. Pages 57–66.

in the classroom with a good phonograph as an integral part or as a separate unit represents fundamental equipment if the teacher is prepared and interested in the effective use of such apparatus. In this connection, I believe that all agencies concerned with educational broadcasting would render a constructive service to education if they were to direct the attention of state inspectors and other representatives of accrediting organizations to the importance of such auditory equipment. Any approach to the problem should include emphasis on proper construction of buildings for an optimum in reception values. I mention this because I taught recently in a new high school building where the estimate of acoustical engineers to condition the auditorium seating 1200 people was $1200.00. Such an auditorium may be directly or indirectly as much of a handicap to the use of auditory aids as is the absence of a good address system. The classrooms, as more important units of building construction, are very commonly not designed to take into account either visual or auditory aids. To avoid waste of the taxpayers' money, I believe that no public school should be erected unless the materials and specifications involved meet high standards as applied to such auditory and visual aids.

As never before, educators are endeavoring to guide the destiny of the American school system from the vantage point of some philosophy of education. Suffice it to say here that "integral enrichment" for the whole teaching process, and as typified by the American School of the Air broadcasts, has the advantage of fitting in somewhat better than "direct teaching" with the democratic theory of education. That is to say, through "integral enrichment"[7] we are in general better able to meet the needs, interests, and abilities of individual students.

Curriculum revisions, even new curricula, which reflect the dominant philosophies of the day are coming into being. Such work is being developed in many cities as well as in a number of states. Under such circumstances, new subjects are being added and old subjects materially changed or eliminated. Such changes are bound to represent unusual opportunities in some form for radio stations dedicated to educational broadcasting. Where some form of an educational board for broadcasting stations, discussed by Abbot,[8] is impractical, an educator with

[7] Tyler, I. Keith. "The Use of Radio in the Classroom," from *Education by Radio,* Columbus, Ohio: Ohio State University, 1936, 258 pp. Pages 244–247.

[8] Abbot, Waldo, *loc. cit.*, pp. 254–255.

special training in the field serving as a consultant would be invaluable.

Of the problems pertaining to educational administration, the relation of fixed broadcasting periods to the variable schedule of given subjects in the secondary school has been most disconcerting. However, as broadcasters and teachers continue to re-examine the increasing values of programs on the air, I feel certain that the schedules of both will fit together for a common good. Beyond that I hope that the radio, in its present and future form, will serve as a potent force in freeing the individual child from some of the evils of our system of mass education. That is to say, I believe that we may yet produce an educational system wherein the needs, interests, and abilities of the child, rather than the minutes of the hour, will serve more fully as the criterion for what the child is to be doing throughout the school day. Let us hope that the influence from the direction of both transmitter and receiver continue to be effective.

Among the practical solutions for radio service to schools is that of radio series suited to extra-class activities. Because extra-class activities, as the term implies, carry on beyond the school day and the school year in order to accomplish many of their objectives, it has been relatively easier to reach the juvenile interest groups through radio programs scheduled outside of school hours. For the past four years, a program of this sort has been conducted under the auspices of the Illinois Junior Academy of Science; a statewide organization of high school science clubs. The programs have included talks and round table discussions by the leading scientists, engineers, and educators of the University of Illinois. Occasionally groups of members from affiliated clubs have presented dramatizations, resumes of national programs, and other work. Some further idea of the nature of the programs may be had from the annual themes as they were presented over the University's station, WILL. These themes have included: "Science and Its Heroes," "Great Events in Science," and, "Opportunities in Science." In no small measure, the cooperation of WILL with the Illinois Junior Academy of Science has contributed toward the growth of the Junior Academy movement as it has spread through a dozen or more states.

In addition to the Damrosch and The American School of the Air broadcasts as classical examples of radio service to the schools, important annual series include those presented under

the auspices of the American Museum of Natural History, the National Advisory Council on Radio in Education, Science Service, and a number of other organizations of national consequence. All these contributions may be expected to add to the wealth of sterling educational material during the current academic year. Contrary to the past, it is believed that a lesser part of this material will have wasted its fragrance on a desert air.

By way of conclusion, I have endeavored to present some facts pertinent to the radio program as an aid in education. In the main, I have presented a picture from the point of view of the classroom teacher at the secondary level where relatively small amounts of effective radio usage are to be found. In various ways I have indicated that radio service in education is receiving more and more attention on the part of educators. Great as has been the service of radio for education in and out of the classroom, I take the position of Cantril and Allport when they say:[9]

> The radio of the future will perform still greater service if its course is guided by a more enlightened public policy, based in part upon psychological investigations and in part upon a sound philosophy of social progress.

Beyond all these considerations we may find encouragement in the fact that radio service is reaching the classroom by more than one route.

[9] Cantril, Hadley and Allport, Gordon W. *The Psychology of Radio*, New York: Harper and Bros. 1935, x+276. Page 253.

A NEW CAMERA TO IMPROVE THE MOVIES

At opposite ends of the country, Rochester and Hollywood are united on one thing—the production of spectacular pictures and the development of new equipment to improve them.

Mr. Carl L. Bausch, director of research and engineering for Bausch & Lomb, is conferring with Walt Disney's technical staff on the improvement of the new multiplane camera by which the illusion of depth has been given to the new film.

The new camera photographs the characters, painted on celluloid sheets, in seven planes simultaneously, each plane thirteen inches apart. An effort is being made to cut exposure time with a new lens design and improved illumination in preparation for Disney's second full-length technicolor film, the Italian classic, *Pinnocchio.*

The results obtained with the new camera are a series of animated paintings with lifelike characteristics rather than mere cartoons. Running one hour and twenty minutes on the screen, the film required nearly two million drawings, of which 250,000 are left in the completed picture. Disney's staff was increased from 200 to 570 animators and the picture cost $1,500,000 during the three years it was in production.

NATURE RECREATION IN CHICAGO

By William Gould Vinal
National Recreation Association and Massachusetts State College, Amherst, Massachusetts

I. *Nature's Endowment* (Niagara Period Through Glacial Period)

Before the four F's—before fish, flowers, frogs or fowl—the region now called Chicago was a Mediterranean Sea with granite islands to the north. Coral fossils indicate that the water was salt, warm, clear and deep. Those are the requirements of the lowly animal. It must have taken eons for a coral sea to gather enough limy ooze to pile up and compress into limestone 250–400 feet thick. Since this same layer sticks out at Niagara Falls it is called Niagara Limestone. Niagara limestone is just the frosting—so to speak—on a 2,000 foot layer cake.[1] *Limestone* is the earliest letter of Chicago's material alphabet. "Jungle days" followed "coral days." Giant ferns and rushes existed above the present level of Chicago and to the south in what is now Central Illinois. It took another eon for jungle days to pile up a great *coal* deposit. The second letter of Chicago's endowment is as black as the first was white.

Then came "ice days"—ice over one mile thick. A great glacier ploughed the land—(except for Northwestern Illinois and Southwestern Wisconsin). Granite rocks were brought from Northern Michigan and Canada to be piled in moraines. Some were dumped in river valleys and backed up lakes which were to determine railroads, streets, and parks. The third alphabet that spells Chicago is *lakes* which were caused by ice.

The level prairies were born from marshes, lake beds, and outwashed sand plains. Why they became prairies instead of forests is a scientific puzzle. It may be due to several factors of soil and moisture. The fact remains that the fertile *soil* which made the prairies was to be the cause of the disappearance of the prairies. Agriculture was to destroy the shooting star and brown-eyed susans. There were to be only remnants of the abundant prairie chickens and the buffalo. The soil was to go to market in the form of *grain* and *meat*—two big items when it comes to spelling Chicago.

---

[1] *A Naturalist in the Great Lakes Region*, Elliot R. Downing. University of Chicago Press. 1922 Unfortunately this type book is out of print.

At first Lake Michigan stood some thirty feet higher and flowed to the Mississippi. Chicago-land was under the lake. Swimming above the city-to-be were wild swans, pelicans and cranes. Inland there were antelope and wild turkey. Later a ten foot divide sent the waters down another 2,000 mile water highway to the St. Lawrence. All this was before the deepening of the Chicago River for the drainage canal which was to restore the water to the Gulf of Mexico. It is the water highways that make it possible to bring to Chicago's doorway ***iron***, another of nature's gifts.

Wherever limestone, coal, iron, grain, and meat go to market, there will be a great city. Chicago is what it is because of nature's endowment.

II. *Early Nature-Journeymen Visit Chicago* (*1673–1857*)

The mound builders and Algonkians grew corn before Columbus saw corn, yet for hundreds of years nature's gifts of coal and iron stood idle. It took the enterprising white settlers to begin the story of present-day Chicago.

The year that New York was taken from the Dutch by the English (1673) Joliet passed up the Illinois and thence down the "Chicagon" stream to Lake Michigan. Father Jacques Marquette (1637–1675) was sick all winter in a cabin "near the portage" (1674). As indicated in his diary, Father Marquette was a naturalist by necessity. March 23. "We killed several partridges, only the males of which had ruffs on the neck."[2] March 31. "Bustards and ducks pass continually." February 20. "We have had opportunity to observe the tides coming in from the lake, which rise and fall several times a day. . . . The deer, which are so lean that we had to abandon some of those we had killed."[2] The Indians brought him pumpkins as well as corn. The fat of the land was thin living.

Over a century later (1778), George Rogers Clark laid a plan before Patrick Henry, the first governor of Virginia, for seizing Vincennes, Kaskaskia and perhaps Detroit. Thus Clark saved Chicago from being a French Canadian Village. In 1784 Virginia ceded the territory northwest of the Ohio to the United States. In 1795 the Treaty of Greenville, Ohio by "Mad Anthony" Wayne with twelve Indian tribes ceded "one piece of land, six miles square, at the mouth of Chicago River." Up to

---

[2] *Jesuit Relations and Allied Documents.* Reuben G. Thwaites (ed.).

Fort Dearborn days everything except in the "Jesuit Relations" was passed down by oral tradition.

Garrison life at Fort Dearborn (1803–1812) was lonely. News was only brought in by hunters and traders. Captain John Whistler following the receipt of supplies (1804) wrote that "the whip-saw can be of little use without files, for oak is the only saw timber available. . . ." Walnut and cherry boards for making tables were declared scarce and "There has been no corn for the public oxen all summer and none can be procured here."[3] William H. Keating (1799–1840), geologist of Long's Expedition (1823) saw a few huts in Chicago and a garrison having difficulty to subsist off the land.

Charles Cleaver reminiscing about the year of 1833[4] mentioned that officers of the garrison had a wolf hunt every Wednesday. While gunning on the Lake shore a mile or so north he "came to a grove of fir trees that were literally full of prairie chickens. We estimated at from 200 to 250, but could not get a shot at them." All cooking was done in the fireplace and water was toted from the river in pails. Plodding oxen literally navigated "prairie schooners" through the spring mud with difficulty. To the south there was 300 miles of prairie with a small belt of timber one-fourth of a mile wide. Except for a small stream in the middle, the river was covered with wild rice.

John Dean Caton arrived in Chicago in 1833. An early lawyer, he was fond of hunting, fishing, and camping. He wrote that "No saint in the calendar has had more devoted or more painstaking disciples than St. Hubert. . . . These persons are lovers of nature unmarred by the hand of man."[5] Today Caton would be a conservationist.

Charles Joseph Latrobe (1801–1875) spent a week in Chicago. Latrobe was somewhat of a nature writer—a stylist of the Washington Irving school whom he accompanied on a trip to Mexico (1834). He wrote "The Alpen-stock" (1829) and "The Pedestrian" (1832). At the time of his visit an Indian Commissioner was trying to hold council and purchase land. Latrobe describes the inhabitants and then the "Birds of Passage":

---

[3] Mile Milton Quaife. *Chicago and the old Northwest* 1673–1835. p. 157.

[4] Charles Cleaver. *Early-Chicago Reminiscences*. 1882. Revised from *Chicago Tribune*. Number 19. Fergus Historical Series.

[5] Hon. John Dean Caton (b.1812). Wrote on *Origin of the Prairies, The Wild Turkey and Its Domestication*, and the *Antelope and Deer of America*. 1877. p. 344. Published by H. O. Houghton & Co., Boston, Robert Fergus Historical Series. Number 21, 1882.

"You will find horse dealers and horse stealers,—rogues of every description, white, black, brown, and red—half breeds, quarter breeds, and men of no breed at all;—dealers in pigs, poultry, and potatoes;—men pursuing Indian claims. . . . The little village was in an uproar from morning to night and from night to morning . . . for the Indians howled, sang, wept, yelled, and whooped in their various encampments. With all this, the whites seemed to me to be more pagan than the red men."[6] Like the poet Bryant who said of the prairies—"They extend so far it is a boldness of the gaze to plunge to their limit" so Latrobe "loved to stroll out towards sun-set across the river, stretching to the northwest over the surface of the prairie, dotted with innumerable objects far and near."

Sarah Margaret Fuller (b. in Cambridgeport, Mass., 1810), a friend of Emerson, Hawthorne, and Horace Greeley, visited Chicago in the summer of 1843. "In Chicago I first saw the prairie flowers. The golden and the flame-like flowers. . . . The flame-like flower (Indian paint brush?) I was taught afterwards, by an Indian girl, to call 'Wickapee'. . . . I enjoyed a sort of fairyland exultation never felt before, and the first drive amid the flowers gave me anticipation of the beauty of the prairies . . . after I had rode out and seen the flowers and seen the sun set with that calmness seen only in the prairies, and the cattle winding slowly home to their homes in the 'Island groves' peacefullest of sights—I began to love because I began to know the scene, and shrank no longer from the encircling vastness."[7]

Another visitor was one Edward L. Peckham, a Providence botanist (1857). He found Chicago "as mean a spot as I ever was in, yet . . . How persons can navigate this dirty city in a dark night without a broken arm or neck is a mystery to me."[8] Evidently the prairie city was still a marsh. 100,000 acres of swampland by an act of the Legislature (1852) was to be reclaimed by drainage. The Board of Sewers (1855) constructed the sewers near the surface. Both streets and houselots had to be raised one to three feet so that they could use the sewers. Chicago had to pull itself out of the mud by its own boot straps. Perhaps for this reason—more than any other—the early nature-journeymen from the East accepted Chicago with a grain of salt.

[6] Charles Joseph Latrobe. *The Rambler in North America*, 1836. 2 Vols. Seeley and Burnside, London.

[7] Sarah Margaret Fuller. *Summer on the Lakes in 1843*. Little Brown, 1844.

[8] Edward L. Peckham "My Journey Out West," *Journal of American History*, XVII, 1923.

III. *Early Resident-Naturalists (1847–1900)*

In the middle of the 19th Century the itinerant naturalists or nature-journeymen were supplanted by the more permanent species-hunters. Space will allow tribute to only four.

Robert Kennicott[9] (1835–1866) was born in New Orleans. His father was a physician and horticulturist. While Robert was a boy his family moved to Wheeling, just north of Chicago. The boy was frail and had little schooling. At seventeen he studied with Dr. Jared Potter Kirtland of Cleveland, a friend of the family who was also a physician and horticulturist. Dr. Kirtland wrote on Ohio mollusks and fishes. He introduced Kennicott to Spencer Fullerton Baird. The *Encyclopedia Britannica* calls Baird "the most representative general man of science in America." He was founder of the U. S. National Museum, the U. S. Fish Commission, and the Marine Biological Laboratory at Wood's Hole. Baird and Agassiz were Kennicott's ideals. William James said of Agassiz that "everyone went down before him, some yielding money, some time, some specimens, and some labor, but all contributing their applause and their God-speed." By the age of eighteen he had made extensive collections and in 1865 made a Natural History Survey of Southern Illinois for the Illinois Central Railroad Company. Kennicott's first paper was on the "vertebrates and mollusks of the Chicago Region" (1855). He organized the museum at Northwestern University (1857) and identified his collections under Baird at Washington (1858). He was encouraged by Agassiz to work on ground squirrels which was published in 1863. In the winter of 1863–1864 Louis Agassiz delivered a lecture in behalf of the Chicago Academy of Science. He recommended Kennicott as the first director. Kennicott felt that the only good museums were on the Atlantic Seaboard. His aim for the Chicago institution was "the making popular of Natural History, and its advancement." He spent three and one-half years collecting in the Mackenzie and Yukon basins under the auspices of the Smithsonian Institution (1859–1862). In 1865 he went on an expedition to Russian Alaska for the Western Union Telegraph Company which planned to connect North America and Russia by a telegraph line. Kennicott saved a Russian member from drowning in the ice filled Yukon River (1866) but soon died from his over-exertion. William H. Dall was a member of the

[9] Karl R. Schmidt. "Robert Kennicott, Founder of Museums," *Chicago Academy of Sciences*, Vol. 7 No. 1. January, 1936. 12 pp.

expedition. Robert Ridgway called Kennicott "Illinois' first and most gifted naturalist." The Chicago "Great Fire" (1871) destroyed all but a few vestiges of his collections. Schmidt has conferred upon Kennicott the title of Founder of Museums, probably in Illinois.

The second Director of the Chicago Academy, Dr. William Stimpson (1832–1872), was born in Roxbury, Massachusetts. His interest in shells was aroused when Augustus A. Gould presented him a copy of his "Report on the Invertebrate of Massachusetts" (1841). His parents felt that his "beach combing" trips were a waste of time and his employer decided that civil engineering was given second place to hunting land snails. For four years he was naturalist on an expedition to the Northern Pacific (1852–1856). He studied his material at the Smithsonian Institution and the results were published in the *Smithsonian Miscellaneous Collections* (Vol. XLIX). His collection of marine shells taken from Maine to Texas were destroyed by the fire of 1871. He died with a broken heart.

It is interesting to note that the corresponding members in July 1877 included such names as *Louis Agassiz, S. F. Baird, E. D. Cope, W. H. Dall, Joseph Henry, Dr. J. P. Kirtland, *I. A. Lapham, and A. S. Packard, Jr.

Although Stephen Alfred Forbes (1844–1930) belongs to the state of Illinois his influence on Chicago natural history entitles him to be included in this story. He had to hurdle the obstacles that many other leading naturalists have had to meet. When he was of college age he saw five years of service in the Civil War. He was so poor that he had to give up his studies at Beloit Academy and borrowed a wheelbarrow to take his trunk to the station (1860). He was fortunate enough to be born in a log house on a small farm. He wrote that "His interest in natural science was determined by an academic tradition in the family, by an agricultural background, by four years out-of-doors experience in the army, by a naturally thoughtful habit, and by a continuing scientific interest after the cessation of his medical studies."[10] Forbes taught school and studied at Illinois State Normal University (1871). He succeeded Major J. W. Powell as curator of the State Museum (1872). He also wrote many papers on how natural history should be taught. He was both director and teacher in the first summer school of Natural

---

* Deceased.

[10] L. O. Howard. "Stephen Alfred Forbes," *National Academy of Sciences*, Biographical Memoirs, Vol. XV, 1934.

History (1875) at Normal which, significantly, was only three years after the first session of Agassiz's school at Penikese. He founded the Illinois State Laboratory of Natural History (1877) and was director until 1917. He was also State Entomologist (1882–1917). He was one of the first to work on aquatic biology and to study the food of birds. Perhaps he should go down as the Father of Economic Biology in Illinois.

Robert Ridgway (1850–1929)[11] was born in Carmel, Illinois, when wild turkeys and passenger pigeons were still abundant. He was always interested in sketching and when a boy mixed his own colors in his father's drug store. Before he knew that there were ornithologists, at the suggestion of his mother, he wrote to the U. S. Patent Office concerning birds which he did not know (1864). This resulted in his becoming a disciple of Baird. He was appointed Ornithologist (1874) and had living quarters in the south tower of the Smithsonian building. His most important publication is *A History of North American Birds, 1874, 1884* (5 volumes). His recreation was horticulture. His writings are both accurate and popular. "Bird Haven," a large tract near his old home at Olney, Illinois is maintained as a memorial and is a shrine to which local naturalists should make a pilgrimage. It is a worthy memorial to the "Father of Bird Study in Illinois."

IV. *The Public Schools and Nature Study (1858–1936)*

Township surveys were devised by Captain Thomas Hutchins, the first Surveyor-General of the United States. Lot 16 of every township north of the Ohio River was designated as a "School Section" (1785).

The first two superintendents of Chicago, John C. Dore (1854) and William H. Wells (1856–1863) were from the New England of Horace Mann. An ordinance was passed in 1855 to establish a Public High School. The course contained Higher Astronomy, Botany, Tate's Natural Philosophy, Youman's Chemistry, Geology and Mineralogy, and the Geography of the Heavens. All of these studies, except Higher Astronomy, were taught in the Normal Department.[12]

Edward Murphy taught the public school (1837). He writes: "I placed an oak sapling, an inch in diameter, on my desk. That afternoon, a Mr. S., who owned the building, came into the

[11] Alexander Wetmore, *National Academy of Science*, Vol. XV. 1934.
[12] Third Annual Report of the Superintendent of Schools for year 1856.

school room, and seeing the walls decorated with caricatures, and the likeness of almost every animal, from a rabbit to an elephant, got in a raging passion and used rather abusive language. I complained,—he became more violent,—I walked to my desk, took the sapling, and shouted, Clear out, which he obeyed by a rapid movement. This trifling incident effectually calmed the ringleaders, some of whom now occupy honorable and respectable positions in society."

In the same report[13] appears the Object Lesson (p. 40). "Another improvement has been the introduction of 'Object Lessons' " or "Lessons on Common Things." "Laying aside the formality of an ordinary recitation, some common object, as a book or a pencil, is brought before the school, and made the subject of familiar conversation between the teacher and her pupils. The object of these 'Developing Exercises' is to give the pupils clear and accurate ideas of the nature and relations of common objects around them, and also to give them such power of expression that they will be able to clothe these ideas in appropriate language." The *Fifth Annual Report* (1859) devotes pages 28–33 to the object lesson and quotes from the Report of the School Committee of Springfield, Mass. W. H. Wells, the Superintendent, goes on to say that "as some of our teachers are not familiar with the process of conducting an 'object lesson' a specimen lesson is introduced in the hope that it may afford some practical hints that will be of service to inexperienced teachers."

In 1861 the first graded course of study in Illinois was written by William H. Wells.[14] There were ten elementary grades and the tenth grade was the lowest (our first grade). The sixth grade (our fifth) studied "Classes of animals, their habits, the Wisdom of God shown in their adaptations,—shells, foreign products, manners and morals." The fourth grade lessons were on "Production and velocity of sound, voice, musical instruments; velocity of light, reflection, refraction, the microscope and telescope, eyes, rainbow, etc.; composition of air and water, wind, fog, dew, etc." The third grade (our eighth) included the study of "magnetism and electricity, and common minerals." The first school laboratory in the basement of the High School (1874) had a "hands off" policy for the scholars.

[13] Fourth Annual Report of the Superintendent of Schools for year 1858. Historical Sketch by W. H. Wells.

[14] *Public Schools of Chicago*, University of Chicago Press 1897. A Sociological Study presented to the Faculty for degree of Doctor of Philosophy by Hannah B. Clark.

The Cook County Normal School (1867), now Chicago Normal College, was the first county Normal in the United States. Daniel S. Wentworth, the first principal (1867–1882) was a graduate of Bridgewater Normal.

Colonel Francis W. Parker (1837–1902) was born in Bedford N. H. He believed that his life with nature on the farm was his real education. His schooling consisted of attending the district school each winter. He began to teach when 16 years old. He read the few available books—the Bible, Pilgrims Progress, and some almanacs. Dr. Edward A. Sheldon's book entitled *Object Teaching* showed him how to overcome formalism in schools. He studied the methods of Ritter, Guyot, and Herbart in Europe (1872–1874). As Superintendent of Schools in Quincy, Mass. (1875) he introduced Nature Study into the curriculum. He did the same as one of the supervisors in Boston (1883). He had the acquaintance of G. Stanley Hall, W. T. Harris, and John Dewey. With this rich background he was appointed principal of the Cook County Normal School (1883) which soon became recognized as a progressive center. To quote from Colonel Parker: "It was our good fortune to take the initial steps in subjects that have since become of general application. The great book of nature, God's infinite volume of everlasting, inexhaustible truth, had had scarcely a place in the courses of study in American schools. True, science had entered some school rooms through the usual text-book methods of learning facts or supposed facts."[15] Colonel Parker had a talk entitled "Nature and the Child." From Cook County Normal (1883–1899) he was called to be the first director of the School of Education of the University of Chicago.

Dr. V. O. Graham, elected president of the Chicago Normal College in 1936, is chairman of the State Council on Conservation and will undoubtedly be instrumental in bringing the science program out of its formal relapse and we hope, again attain an enviable record for one of the oldest teacher training institutions.

Professor H. H. Straight, a pupil of Agassiz, entered upon the work with boundless enthusiasm. Field excursions were introduced but "Failures in nature study were the rule until Wilbur S. Jackman, in 1889, undertook to grapple with the problem. The idea of thorough, exhaustive work was abandoned. The phenomena of the 'rolling year' were taken as the general

[15] *Elementary School Teacher*, June 1902. Francis W. Parker Memorial Volume. p. 765–76.

guides; the child was brought into loving contact with nature."

Wilbur S. Jackman (1855–1907) was born in Mechanicstown, Ohio. He became interested in nature when his parents bought his great-grandfather's farm at California, Ohio. He rode horseback to California Normal. He graduated from Harvard in 1884. His success as teacher of natural science in the Pittsburgh High School attracted the attention of Colonel Parker who invited him to Cook County Normal. He wrote *Nature Study for the Common Schools* (1891) and became editor of the *Elementary School Teacher* (1904). Jackman was succeeded by Ira B. Meyers in about 1905, who was followed by Otis W. Caldwell. In 1911 the dynasty of Elliot R. Downing commenced. Dr. Downing is another New Englander—in fact a Bostonian. As editor of the *Nature Study Review* (1911–1917) and as editor of the *University of Chicago Nature Study Series* he is nationally known. Today that genius of teachers, O. D. Franks, is the chief factum factotum at the University of Chicago. This is a noted legion dating back to Agassiz as does the early history of the museum naturalists.

It was during the liberalizing days of Parker and Jackman that the Natural Science Section of the Illinois State Teachers' Association was organized in December, 1888 and held its first meeting December 27, 1889. Professor S. A. Forbes was elected president. At the first session Professor Forbes read an important paper on the "History and Status of Public School Science Work in Illinois." He attributes the fact "that this fruitful movement arose earlier and went further here than elsewhere" to Professor Jonathan B. Turner who "in 1851 called a convention of farmers in Putnam County to consider education toward the farm." As early as 1868 the State Natural History Society assumed "the duty of supplying natural history materials to schools prepared to use them."

In 1894, in the revised course of study, oral instruction or object lessons became Nature Study "to assist in breaking down the unnatural barriers which the artificial environment of city life have built up between the child and nature, and to recognize the originality and individuality so valuable to the citizen."

It was in about 1884 that Ecology began to assert itself. In subject matter and method it is nothing more than advanced Nature Study. In 1902 the first course in Animal Ecology was given by Dr. Charles C. Adams, now Director of the New York

State Museum,[16] at the University of Chicago. The names of V. E. Shelford and Henry C. Cowles have also been potent in the Illinois Ecological Center. In 1918 Dr. Cowles was president of the Ecological Society of America. His *Vegetation of Sand Dunes of Lake Michigan* (1899) is a source book for enterprising field leaders.

Under the stewardship of William J. Bogan, Superintendent, a new "Course of Study in Science and Nature Study" was adopted July 22, 1931 and Paul G. Edwards was appointed supervisor. Unfortunately the depression gave the work a setback when it was needed most. Dr. William H. Johnson, the new Superintendent (1936), is inheriting a rich tradition of nature education. It is with keen interest that the leaders who know the story await the "March of Time" in Chicago nature education and recreation.

Compared with eastern cities, Chicago has grown up in double quick time. By 1930 it was a typical American city with one-quarter its population of foreign birth. The rate of growth has made the problems more chaotic and more baffling. Sometimes the schools have been kept open with difficulty, but through it all has run the New England tradition that welfare depends on education. In the melting pot elementary science has its place, for science teaches us to believe in change, to withstand unreliable propaganda, to know that there is a law of cause and effect, to seek the outdoors as a preventive of mental disorders, and to meet the unnatural situation of a bread line in the city and a surplus on the farm. The understanding of the complexity of growth of the elementary science program in Chicago is necessary to a clear understanding and an intelligent planning in the future.

V. *Nature's Gifts Go to Market* (*1847–1936*)

The Chicago cog-wheel that ties nature's endowment to nature culture is industry. The picture cannot be complete without viewing this steel framework that makes the finished structure possible.

If the greatest ocean highway is between New York City and Northwest Europe, the greatest land pathway is the Mohawk Valley which leads from Chicago to New York. The Chicago portage has become *the* portage of portages. Before the

---

[16] "The New Natural History—Ecology." *The American Museum Journal*, Vol. XVII, No. 7, pp. 491–494. 1917.

flat boat and the covered wagon, the buffalo and the wild duck migrated via Chicago. It is not mere chance that it is on the pathways of the nation nor the terminal of 33 great trunk railways. Land, water, and air routes converge at this "heart of the nation."

Chicago's bank account goes back to its hinterland—when peat bogs had formed coal—when the plains and lakes were set for easy haul—when the wealth producing soil was ready to produce grain—and when the structural materials—iron and limestone—were put to work. The 20 inch rainfall line placed the agricultural wealth at Chicago's dooryard. The conifers of the north and the broad-leaved forests to the south determined the world's furniture mart. When someone discovered that "corn goes best to market on all fours" and that hay goes to market in the form of beef and dairy products, the greatest packing industries in the world were created. Out of this mutually dependent and mutually beneficial wealth came such well known names as Deere, McCormick, Armour, Swift, and Marshall Field. Out of material development has come vision and culture.

It was John Deere, the blacksmith, who finished the first steel plow (1837). It was Cyrus H. McCormick (1809–1884), the Virginia farmer boy with a common education at the "Old Field School House," who at the age of 15 constructed a grain cradle. His father thought that he was wasting time but, like William Stimpson, he could not be side-tracked. McCormick invented the first practical reaper (1831) and demonstrated how standing grain could be cut by machinery. William H. Seward said "Owing to Mr. McCormick's invention, the line of civilization moves westward thirty miles each year." It was due to his foresight that the factory was established in Chicago (1847). The McCormick Companies and the Harvester Company, built up by William Deering, merged in 1902 to form the International Harvester Company, which has long played a leading part in the manufacture of agricultural machines. The world's largest farm machine factory has a floor area which would extend seven miles if 100 feet wide. In celebrating the Reaper Centennial (1931) a rock garden was made of native rocks from each of the 48 states. The Company is noted for its interest in the welfare of its employees and in the farming public. The National 4-H Club Congress is held annually in Chicago and each year it is entertained at the International Harvester plant.

One of its noted educational exhibits is the reproduced Holstein cow which chews its cud, blinks its eyes, moves its head and ears, switches its tail, breathes, moos, and gives milk. The Company has a film department. Typical of its publications is a 70-page illustrated pamphlet entitled *Young Folks Do Something and Be Somebody* (1930). On page 13, for example, there is the title "Training is Important in Making Us What We Are." There is a picture of a boy feeding a calf which has the title—"As a calf grows, it develops habits." Beside this there is a picture of a boy at the table with the title—"As we grow, we develop habits." Midway down the page it says:

"*Training is important.* A wild calf from a Western ranch has no chance to win the prize in the show ring when placed beside the well-conditioned, well-trained calf owned by a 4-H club boy. Fortunate are the boys and girls whose parents and teachers do a good job of conditioning or training them"——

Each page is cryptic and vivid. No young person or leader can miss the idea. It is given in the form of an every-day experience. It is Benjamin Franklin's philosophy in up-to-date language. Written in terms of corn, pigs, orchards, puppies, and eggs, it is one of the best textbooks in nature education that we have seen.

Rudyard Kipling did not praise Chicago. "How I struck Chicago, and how Chicago struck me. Of religion, politics. and pig-sticking, and the Incarnation of the City amc Shambles."[17]

I know thy cunning and thy greed,
Thy hard high lust and willful deed,
And all thy glory loves to tell
Of spacious gifts material.

It is with regret that we limit this section to one science hero and how he prospered in the Chicago business world to later bring it education and culture. The remainder of the treatise will emphasize the nature cultures that have resulted from Chicago's giants in industry. Kipling could not have realized that at the time of his visit industry had been on its feet for only about 50 years nor could he have predicted the great cultural era that was about to follow his visit. There are things to realize before sizing up Chicago. The "Windy City" is no more windy than Boston or Manhattan. Racketeers and crime are perhaps featured more but occur less than in many unan-

[17] Rudyard Kipling. "From Sea to Sea": *Letters of Travel*, Part II. Scribner's. 1906. pp. 230–248.

nounced centers, and there are people alive who were born before Chicago was a city.

VI. *Chicago Nature Culture (1900–1936)*

On the National Academy of Science at Washington appears the following quotation from Aristotle:

> Search for truth is in one way hard and in another way easy, for it is evident that no one can master it fully nor miss it wholly, but each adds a little to our knowledge of Nature, and from all the facts assembled there arises a certain grandeur.

If one should name the "seven wonders of Chicago" at least four of them would be from the following list of science institutions. All of these science cultures have arisen with grandeur and each is based on a past lineage. For the most part they have appeared in the last quarter of a century.

1. *The Chicago Academy of Science* (1847) is the oldest scientific body in Chicago after the Chicago Medical Society. It is a peculiar mixture of the old and the new. The specimens are arranged in order. The large shell collection takes up an undue amount of space. The backgrounds of the habitat groups are enlarged photographs colored by hand. One background is 92 feet long. The sand dunes of Indiana are particularly fine and the transition from objects to painted scenery is skilfully done. The colored transparencies of the Chicago region are very attractive. The Academy is cooperating with the Chicago Park District in planning a series of exhibits for the various field houses under the direction of Earl G. Wright. Besides furnishing slides and films for school use it has many publications of local natural history including minerals, reptiles and amphibians, birds, shells, mushrooms, mammals and dunes. *At Home with the Birds* by Alfred M. Bailey, Director of the Academy, has pictures painted from life by Earl G. Wright and sells for ten cents.

The Atwood Celestial Sphere, invented by Wallace W. Atwood, was a forerunner of the Adler Planetarium. The diameter of the sphere is 15 feet and it weighs 500 pounds. It has been in daily use since 1913 and shows approximately the 692 stars visible from Chicago.[18]

2. *The Chicago Park District* (1860). Lincoln Park is the pioneer of Chicago Parks. It was ceded by Congress to Illinois in 1828. In 1837 the state granted it as a cemetery. In 1860 the

[18] *Bulletin of the Chicago Academy of Sciences*, Vol. IV, No. 2, May, 1913. 38 pp.

northern end was reserved as a public park and the Council forbade further sale of lots and interment of the dead. The sand hills were covered with pines, occasional willows and scrub oaks and a rank growth of poison ivy (up to 1874). The North Park Commission was created in 1865 by the State Legislature and by 1866 the area was dedicated to the living. A ditch went through the park for drainage purposes and the barren shifting sand dunes gave little promise. As late as 1871 the residents of North Chicago pastured cows there. Frog-fishing was a favorite sport along the ditch. The Humane Society presented a stone fountain for watering horses (1877) and the statue of Linnaeus was a gift of Scandinavian citizens. As late as 1877 the flower beds were planted in masses so that the police could protect them.

In 1874 the Commissioners ordered 37 pairs of English sparrows at the low cost (?) of $1.50 a pair. In 1892 the Chicago Fly Casting Club asked for the privilege of fly casting. Although gold fish are carp this was considered an insult to the fish. Unfortunately the picturesque scrub oaks were grubbed out and weeping willows were put in their place. Today the nearest remnant of native sand dunes is at Waukegan. The 1,500 acre Indiana Dunes Park, 40 miles to the southeast, is where Chicagoans tip the Hoosier State to get a notion of Chicago's lake front as it was in the beginning, with its sea rocket, beach pea, sand cherry, and sand pipers. When the first tennis court was opened a taxpayer, who claimed equal rights with the players, started a sit-down strike in the middle of the court.[19] And now 3,000 roomed hotels and the "Gold Coast" on Michigan Boulevard stand where once the waves of Lake Michigan beat upon the shore. Chicago has the biggest front yard of any city in the world. The Park Board is in the Century of Progress Office Building. The debris of filling is being covered and the W.P.A. is landscaping the lagoons, islands, and boulevards. The history of Lincoln Park represents an enormous change in park thinking and planning.

Garfield Park has the largest public owned Conservatory in the United States (1907). It is 65 feet high, has 68,055 square feet of floor space, 300,000 specimens, and 3,000 species. There are seven rooms which have different temperature and humidity and thirteen propagating houses. The walks and original plan-

---

[19] Bryan, I. J. *History of Lincoln Park* (Chicago). Published by the Commissioners of Lincoln Park, 1899.

tations were designed by Jens Jensen. Here one can see coffee trees, banana trees, tea shrubs, rubber trees, cocoanut palms, fig trees, mango and bread fruit trees. Lorado Taft called it a piece of fairy land. Near the entrance is a fern-bordered pool flanked by Lorado Taft's beautiful groups "Pastoral" and "Idyl." He said that "The little whimsies have no great burden of significance. They represent care-free maidens and faun-like youths of some remote period as they might idle and play in the forests of Arcadia. It was my thought merely to make something graceful and appropriate for the greenhouse, something that would add to the impression of fairyland which strikes all visitors in that wonderland place."[20]

The Chicago Park Consolidation Act became effective in 1934. Before this there were twenty-two park districts—each an independent municipal corporation. Today it has an annual appropriation of nine million dollars and three million of this is being devoted to recreation. Three thousand employees, 134 parks with 5,000 acres, and 162 miles of boulevard are other figures that go to show that this represents big business. The Landscape Division alone arranges a continuous showing of flowers in the three larger conservatories, educational work in a series of garden lectures at several centers, and special articles for the newspapers. They maintain a regular guide service, fifty acres of flower beds, and plans have been made for a school for florists (1936) at the Garfield Park Conservatory to replace the uninterested, unintelligent laborer. Each apprentice will be required to attend regular classes and there will be annual examinations upon which promotion will depend.[21]

3. *The Brookfield Zoo* (1868). America's first Zoo was at Philadelphia (1859). Chicago's zoological collection began with two pairs of swans from Central Park, New York (1868). Brookfield Zoo, the world's largest, with its animals cageless and apparently in their native habitat, opened in 1934. It cost over four million, has an annual budget of $300,000, and requires 60 buildings. Zoos are no longer mere "show places." They are meccas for students, artists, and other craftsmen. This is especially true at Brookfield. The Zoo, as far as possible, has its 5,000 animals amid natural surroundings where they may be observed first hand. It even includes that rare animal, the duck-billed platibus of Australia. Educational lectures re-

[20] *Catalog Guide 1924.* Published by West Chicago Park Commissioners.
[21] Chicago Park District. First Annual Report. 1935.

corded on phonograph discs are broadcast at intervals in the main exhibition halls. Edward Bean, the Superintendent, believes in tying up with the public school system.

The Jackson Park Bird Sanctuary was dedicated in 1936. The idea originated with Bob Smart. Twenty acres have been set aside for the raising of quail and woodchucks and for attracting migratory water fowl; 5,000 shrubs and vines have been set out because of their fruits. Several thousand aquatic plants and 100 bird houses have also been added.

4. *The Columbian Exposition* (1893). Although the Columbian Exposition in itself was temporary, the "White City" of 1893 was an object lesson that has had a permanent influence and like the Century of Progress was worth all the millions paid for it. For example, its row of aquaria showing saltwater fish, fish of the Great Lakes, and fish of the Mississippi was possibly a forerunner of the Shedd Aquarium. As so strikingly said by V. K. Brown, "The Columbian Exposition came at a time when parks resembled the old-fashioned parlor. They were proper places . . . with everyone stiffly on his good behavior, rigid as rigor mortis. The Fair profaned the park. . . . But left also a new daring in the imaginations of men."[22]

5. *John G. Shedd Aquarium.* The word largest seems to be peculiarly Chicagoan. Whether it would always stand the test is unknown to the writer. The Shedd Aquarium is said to be the largest and most completely equipped in the world. Mr. Shedd gave three million to build and equip this marble home for fish. He noticed that the Government Fisheries Exhibit at the World's Fair (1893) attracted the most visitors. The 8,000 fishes represent 345 species ranging from half-inch tropical, or toy fish, to the 585 pound sea-cow or manatee from Florida. It includes the electric eel, the sea horse, and hermit crabs. The salt water was brought from Key West in 160 tank cars and is expected to last twenty years. The "Balanced" acquarium room has 65 smaller acquaria with small tropical fish. Snakes, frogs, and turtles make their home in a central rock garden. That Walter H. Clute, the director, became interested in fish while convalescing suggests that a "bowl of tropical fish" may be as challenging and perhaps more satisfying than the usual "bouquet."

6. *Field Museum of Natural History* (1893). The Field

---

[22] V. K. Brown, Chief of Recreation Division. Chicago Park District. "Present-Day Parks and Their Functions, *Recreation*, January, 1937.

Museum, founded by Marshall Field, is an outstanding example of how a large business has returned its profits to a community in the form of culture. The building is a gem in marble, valued at seven million dollars. It occupies an area of eleven acres. The main entrance opens into the Stanley Field Hall. In the center are two African elephants mounted in fighting attitude. These were secured on a museum expedition to British East Africa in 1906 and the group is the work of Carl E. Akeley. Toward the rear of the hall there is another Akeley production —three bronze groups illustrating lion spearing by native Africans. Extending from the Stanley Field Hall there are various halls and departments. The N. W. Harris Public School Extension Department, endowed by Norman Wait Harris, prepares portable cases of Natural History and lends them to the schools of Chicago. The James Nelson and Anna Louise Raymond Foundation for Public Schools and Children's Lectures has a $500,000 endowment (1925). Miss Margaret Cornell, formerly the progressive nature leader at the North Shore Country Day School at Winnetka, has been the efficient head of this work since 1929. Programs are presented in the James Simpson Theatre and groups are conducted on tours through the Museum. The education staff also visits schools. The Museum also sells valuable sets of educational post cards (6–16 cards to a set, 10–30¢).

7. *Cook County Forest Preserves* (1915). The Forest Preserves represent a 51 square mile recreational domain which surrounds Chicago. The belt of woodland will be about four miles wide. The "Forest Way" will be 660 feet wide wherever possible and will link these areas. There will be one way 40-foot master drives separated by a forested strip. In 1930 a two and one-half million bond issue was passed to support the project. The Forest Preserves have their own fire and police patrol. The Trailside Museum at Thatcher's Wood, under the leadership of Gordon Pearsall, is a prophecy of what will be an enormous undertaking in nature recreation.

8. *The Morton Arboretum* (1921). J. Sterling Morton, a Nebraska pioneer and Secretary of Agriculture (1893) under Grover Cleveland, instituted Arbor Day. It is fitting that the family property in Nebraska has been given to the State as a State Park. J. Sterling Morton was a nature lover. Arbor Day has been made a legal holiday in Nebraska (1885) and the Legislature set aside Mr. Morton's birthday—April 22—as a day for tree planting.

Joy Morton, the son of J. Sterling Morton, and Chairman of the Morton Salt Company, founded the Morton Arboretum at Lisle, Illinois (1921), 25 miles west of Chicago. It is a unique experimental laboratory for woody plants which carries on scientific research in horticulture and arboriculture. The tract consists of over 700 acres and approximately 4,500 species, varieties and hybrids. The Administration Building, housing the Library and Herbarium, is a "symphony in wood." The butternut panels at the entrance, the thin lamp shades, and the blinds show the wood grain that we are now demanding in our cabinets and interior finish. The living plants are arranged according to classification, for landscaping effects, and in geographical groups. The Arboretum is also a bird sanctuary. Bulletins of popular information are issued for tree lovers.[23,24]

9. *Adler Planetarium* (1930). The Adler Planetarium and Astronomical Museum is the first in America and was made possible by Max Adler, Vice-president of Sears, Roebuck and Company. The inscription reads: "The Astronomical Museum and the Planetarium of Chicago. Gift of Max Adler. To further the progress of science—to guide to an understanding of the majesty of the heavens—to emphasize that under the great celestial firmament there is order, interdependence and unity." This "Theatre of the Sky" cost one million dollars. The dome is 72 feet in diameter. Around the cornice, where the white dome joins the walls, the Chicago skyline as seen from the doors of the planetarium appears in silhouette. The Zeiss projector with its 119 projectors, was built at Jena, Germany at a cost of $90,000. The constellations and other figures thrown on the dome are pointed out by a "finger searchlight." Twelve topics are presented—one a month—such as The Midnight Sun for June and the Heavens at the North Pole. The "Music of the Spheres" by Rubenstein is a favorite accompaniment. During the first year nearly a million people attended.[25]

10. *The Museum of Science and Industry* (1933). The Museum of Science and Industry was founded by Julius Rosenwald. It goes back to the Deutsches Museum created by Dr. Oskar von Miller where there is no "verboten" sign but where you can push a button and see how it works. It was opened in 1933 with the "Century of Progress Exposition" when the visitors could

---

[23] *Facts about the Morton Arboretum*, published by the Arboretum.

[24] "Morton Arboretum at Lisle, DuPage County, Ill." Extension of Remarks of Hon. Frank R. Reid of Illinois, in the House of Representatives, March 4, 1929.

[25] Philip Fox, *Popular Astronomy*, Vol. XL, No. 3, March 1932, pp. 31.

descend into a coal mine and see it in operation. The museum aims to reveal the technical ascent of man from cave man to engineer. The old Fine Arts Building of the World's Columbian Exposition was rehabilitated by a five million dollar bond issue and altogether represents an investment of 30 millions. Here one can see the laboratory of Michael Faraday and how wood pulp is changed to silk and coal tar to perfume. Under transportation we witness Stephenson's "Rocket" (1829), the historic wood-burning "Mississippi" (1836), a model of Robert Fulton's Clermont, up to airplanes and dirigibles. In the future they plan to have a South African diamond mine, Bessemer furnaces, peat to anthracite, a garden of coal fossils, the forest of the Coal Age, and a blast furnace. Literally it is a pageant of civilization in ten miles of exhibits.

11. *The Century of Progress Exposition* (1933). The exposition has gone. The third Fort Dearborn remains—perhaps to be used for a museum. The influence of the Century of Progress —like that of the Columbian Exposition—will last for a long time. In this preview of science in the future the machinery was started by a beam of light from the star Arcturus launched into space forty years before and caught by a silenium cell. Forty years before President Cleveland pressed an electric button. The roof of the Agricultural Building was made of corn stalks. The futuristic Aladdin City is to be an age of steel, chromium, aluminum, and electricity. Most buildings were windowless and illuminated by electricity. The flaming Niagara, Aurora Borealis, fog effects, and "Electric jewels" were spectacular—all of which showed the mastery of man over the forces of nature.

12. *The Illinois State Natural History Survey* (1917),[26] was formed by the merger of the state entomologist's office (1867–1917) and the State Laboratory of Natural History (1877–1917) and was administered by Stephen Alfred Forbes until his death (1930). He was succeeded by the present Chief, Dr. Theodore H. Frison. The Survey is state sponsored but operates under a board headed by eminent scientists who control the research program. It aims at good game laws, fisheries problems, mammals and upland game problems, and insect control. It has a cooperative arrangement with the Chicago Academy of Science. It holds field trips for teachers, 4-H Clubs, and Izaak Walton

---

[26] Available Publications of the Illinois State Natural History Survey. Theodore H. Frison, Chief. January, 1937.

League. It expects to have a public relations man and a Conservation Commission plan for the State of Illinois. Chicagoans should be concerned not only from a general interest in conservation but because of the proposed Calumet Lake Wild Life Sanctuary and the Waukegan Dune Reservation.

VII. *A Few Human Interest Stories from Chicago—1936*

Nature Recreation exists in Chicago as it does in every city. A census would show thousands of people with a nature hobby. There is Sam Jasperson, for example, at 304 Crawford Street, who has the walls of his barber shop covered with Indian relics. Conversation there easily turns to Indian culture. He says that he has 10,000 artifacts. A visit to see his collection is convincing.

One of the most fascinating stories is of Samuel Bornstein who came from Russia as an immigrant in 1914. Someone told him to study English and to become a tailor. Although a born adventurer and idealist he did not know of any other way to turn to get a living. He studied English at the Jewish People's Institute for a year and a half and then disappeared for twenty years. One day a stranger appeared in the office of Dr. Philip L. Seman and said: "Do you remember me?" Since Bornstein was only one of 1,400 who studied English that year Dr. Seman did not remember him. He had been a world traveler and collector for all this time. In pay for his first contact with the institution he wanted to present his collection of 5,000 specimens. Would Dr. Seman go and see the collection? After four visits and invitations Dr. Seman was able to leave his desk to see the curios. It was nine o'clock on a hot summer night. The stairs on the two storied house were dark. The flat was practically empty except for many trunks and a squatty woman. Bornstein disappeared. Dr. Seman had time to think. His family didn't know where he was. Perhaps after luring people there they robbed and even put the remains in trunks. Bornstein returned with a lighted candle. He apologized for the light but said that the gas had been turned off as he had no money to pay for it. He started to open the trunks. All kinds of objects had been packed in newspapers and cloth. Dr. Seman thought that he was in fairyland.

It took six months for Bornstein to bring his loved possessions to the Jewish People's Institute in a suit case. They were set up in a room next to the library. Some of the specimens were so unusual that a library must be handy. One day when he was

setting up his museum he went to Dr. Seman and said: "I do not want anything for my work in the museum. It is my life. Can't you help me get a job so that I can give my free time?" Dr. Seman finally succeeded in obtaining him a job in a department store. The museum is insured for $45,000. It was given by an appreciative immigrant who couldn't pay for his gas bill. Every evening, except Friday, Bornstein is in the midst of his museum answering questions to hundreds of visitors. Perhaps he will show you a ceremonial robe given him by a Chief in Borneo. Bornstein made the Chief understand by a sign language that if material could be had—he (Bornstein) would make his honor a fitting garment. Friendship grew and the Chief was so pleased that he presented Bornstein his best robe. So here is a tailor who is curator of his own museum. He writes books in Yiddish for children. He writes poetry. Perhaps he is a Michelson or an Einstein in the rough. It is certain that as a tailor he was a square peg in a round hole. There was no one to discover him. And so today there are in every community diamonds in the rough. Our system has no way of mining them.

At Oak-Park a ground-keeper saw some boys pulling up flowering plants from the border. He bought potted plants and gave them to the boys. This time at least the plan worked and he had no more trouble. At Dvorak Park, Frank Smrz, one of the custodians, has tropical plants which are flourishing in the boys' shower bathroom where the humidity and temperature seems to be at its optimum. Delinquency runs high in the neighborhood but Mr. Smrz has no trouble. Apparently he is able to maintain discipline through his greenhouse. It is apparent that oftentimes the laborers at a community center are the ones who see the opportunity in nature recreation.

VIII. *Nature Recreation A Major Chicago Problem (1937–1950)*

From primeval mud to bricks, to boulevards; from marine coral reefs to enormous dinosauria to mastodons with cranial limitations; from the thousand years of the red man who couldn't put iron to work to the short span of the white man who has built marble monuments from iron and coal; from time immemorial there has been the natural law of *change*. The mastodon couldn't adapt himself to change and he is in the Field Museum. Changing conditions are still at work. It is a long road from vampires to aeroplanes, from depressions amongst

tropical ferns and armored fish to palmy days for Japanese dish gardens and tropical fish, from running down the buffalo to game management and sterilization.

Chicago's geographic pioneers have been succeeded by scientific pioneers. Nobody but the municipality can recover a water front, or set aside 20 acres of swamp planted with wild rice as a refuge for water fowl, or place a closed season on prairie chicken, or handle public health, or dig a drainage canal, or plant a forest belt, or provide for the use of parks. Chicago has spent millions to make possible nature recreation of all forms. The combined physical plant—in true Chicagoan language—has not been surpassed. Today gold lies buried in Chicago's lake front in the form of museums, vistas in landscapes and in waterscapes. How are the men and women who stand behind counters and machines going to stir their imaginations when they go to Lincoln Park for fresh air? Not more than one out of forty can take advantage of any of the mental or spiritual assets of this new area. Ultra-violet rays will help but there must be mental stimulation.

The *what* of Chicago's nature story has been told. Capitalism has provided culture. The city has provided great undertakings in art, music, and drama. Most of Chicago's nature culture centralizes around Lincoln Park. Nature culture also exists at Pulaski Park where geodes of calcite crystals may be discovered. The *what* of nature is there also but the *why* of nature is untold and unseen. Obviously the Pulaski Park nature assets could be made more adequate and the leaders more competent in nature lore. With recreation schools for the park police and a training school for laborers in the landscape division, leadership training for nature guides does not look impossible. The Recreation Division must lead the way but the mobilization must also be a neighborhood responsibility. There is no better activity on which a neighborhood can focus appreciation and with which it can practice cooperative citizenship. Nature hikes for boys and girls should be a community provision to sustain a healthful, happy outlook on life. Nature recreation is democratic. It offers a diversified, inexpensive program for all people. In the same way that the modern incandescent lamp saves a million a day so nature recreation can end nature plunder, and provide mental and soul satisfactions. It is a public utility. Parks and museums are the birth places of these new activities. The surface has not been scratched. A new order of public welfare is possible.

ALGEBRAIC TREATMENT OF EUCLID'S GEOMETRY*

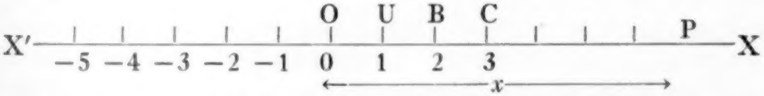
By John A. Swenson
Columbia University, New York, New York

At the beginning of the seventeenth century, mathematics had already been studied for over two thousand years. The geometry of Euclid, being born about 300 B.C., had been studied and improved by generation after generation of mathematicians, and by the seventeenth century mathematics had passed through the minds of Egyptians and Greeks, of Arabs, and of Germans. And yet, after all this time and labor, one of the greatest and most fertile of ideas in all mathematics came to the French philosopher and mathematician Rene Descartes. This happened one morning as he lay in bed. The idea was perfected and given to the world in 1637 under the name of Analytical Geometry. In this new geometry, Descartes showed the world how to picture numbers, and how to represent geometric loci by algebraic equations.

The core of the ninth year mathematics at the Andrew Jackson High School in New York City is a simplified Analytical Geometry. The work begins with the setting up of a one-to-one correspondence between numbers and the points on a line.

The function concept may be treated from two different angles: correspondence and dependence. The former predominates in the work that follows.

The setting up of this correspondence is done in the following manner. Let XX' be the line on which the numbers are to be represented,



O the origin, OU the unit of measure, and the length of the line-segment OC 3 units. Then we may regard the point C as representing the number 3. We also say that 3 is the coördinate of the point C, and more generally that the coördinate of P is x if the line-segment $OP = x$. By subdividing the unit OU into equal parts, we can picture the fractions in very much the same way as the integers. In this manner, there is set up a

* Presented at the Mathematics Section of the Annual Convention of the Central Association of Science and Mathematics Teachers, Cincinnati, Ohio, November 26, 1937.

one-to-one correspondence between integers and fractions and points on the line chosen for representation.

Next we show the pupil that there are other numbers besides integers and fractions. This is done by considering the following problem in correspondences:

1	2	3	4	5	6	7	8	9
1	4	9	16	25	36	49	64	81

If we now fill in the missing integers in the lower line as far as 9, we obtain the following:

1	x	y	2					3
1	2	3	4	5	6	7	8	9

Let us now find, if possible, the numbers in the upper set which correspond to the numbers 2 and 3 in lower set, respectively. It is evident that no integers meet this requirement. Let us try fractions, say tenths.

1	1.1	1.2	1.3	1.4	x	1.5
1	1.21	1.44	1.69	1.96	2	2.25

Hence x lies between 1.4 and 1.5, and next we use the hundredths 1.41, 1.42, 1.43, etc. In this manner we can readily convince the student that the exact value of the square root of 2 cannot be expressed by using integers and fractions, and that a new symbol is needed. For this purpose the symbol $\sqrt{2}$ is introduced and with it the idea of irrational numbers. Hence $\sqrt{2}$ represents such a number that $\sqrt{2}\cdot\sqrt{2}=2$. The pupil also realizes that the rational numbers 1, 1.4, 1.41, . . . are approximate values of $\sqrt{2}$ and this leads to the idea of significant digits and computation with approximate numbers. The plotting of the numbers 1, 1.4, 1.41, . . . as coördinates on a line leads to the limiting point which has the coördinate $\sqrt{2}$. This leads to the following axiom of continuity:

Corresponding to every rational and irrational number there is a point on the line chosen for representation, and conversely, to every point on the line corresponds a number, rational or irrational.

The full understanding of this axiom is, of course, not possible for the pupil at this stage, but the teacher can make the pupil approach this understanding more and more as the march through mathematics goes on.

In this manner, there is established a system of coördinates on a line and a fairly complete analytical geometry of one dimension is brought about, dealing with such topics as: directed line-segments, loci, distance formula in one dimension,

finding the coördinates of the points which bisect, trisect, etc. given line-segments, complete and partial converses of theorems in one-dimensional geometry, positive and negative numbers, transformation of coördinates in one-dimensional geometry, arithmetic mean by using an assumed mean.

It is, of course, impossible to deal here with these topics in detail on account of the lack of space, but we can state some of the actual problems solved by the pupil.

1. Ray CX contains all the points and only those points whose coördinates are not less than . . . . Hence ray CX is the locus of . . . . (Use figure given above.)

2. Name three rays which contain only points whose coördinates are greater than 2 but which do not contain all such points.

Note. Problems like the last one are intended for the introduction of necessary and sufficient conditions.

3. Find the coördinate of B, if the coördinate of A is -2 and the directed line-segment $AB = +7$.

4. Find the coördinate of the mid-point of AB if A has the coördinate -8 and B has the coördinate $+4$. Find also the coördinates of the trisection points. Generalize this problem by letting A have the coördinate a and B the coördinate b.

5. If A, P, and B are three points on a line with coördinates 2, x, 11, respectively, and $AP+PB=AB$, show that x may have any value whatsoever.

Note. This problem is intended to introduce identities.

6. If A has the coördinate 4, B the coördinate 10, and M is the midpoint of segment AB, then the coördinate of M is 7.

(a) Prove this statement and examine the validity of the total converse.

(b) Form the three partial converses of the given statement and prove the truth of each.

This is followed by the introduction of such geometric concepts as: (a) extending, rotating, and translating line-segments, (b) angles, their supplements and complements, (c) polygons, (d) algebraic problems involving these geometric concepts.

Next an analytical geometry of two dimensions is established by setting up a one-to-one correspondence between points in the plane and ordered pairs of numbers. The following fundamental assumption is made: two perpendicular lines and all the lines perpendicular to them form a network of rectangles. The fact that the graph of an equation of the first degree in one or

two unknowns is a straight line is verified experimentally, but a logical proof is, of course, impossible at this stage. It is also verified experimentally that a straight line has a constant slope or a constant difference ratio. Hence the last two facts are listed as assumptions. The delta notation is also introduced at this stage.

A modified form of the three congruence theorems is now introduced. The first one (s.a.s.) is verified experimentally, but the second and the third are proved by the indirect method.

Parallel lines are defined in the usual way and followed by the following theorems:

1. If two lines have equal difference ratios, then they are parallel. Method. Show that if $y=2x-3$ and $y=2x+5$ are the equations of two lines, then if they intersect we are led to the impossibility $2x-3=2x+5$ or $-3=+5$.

2. If two lines have unequal difference ratios, then they intersect. Method. Show that $y=2x+3$ and $y=3x-5$ have a common solution.

3. If two lines are parallel, then they have equal difference ratios. Method. Indirect proof by contradictions from 1. and 2.

4. If two lines are parallel, then they form equal corresponding angles with a transversal. Method. Since the lines are parallel they have equal difference ratios. Now use congruent triangles.

5. If two lines are parallel, then they form equal alternate interior angles with a transversal.

6. Converse of 4.

7. Converse of 5.

8. The sum of the angles of a triangle is 180°.

9. The opposite sides of a parallelogram are equal.

Oblique networks are now introduced and it is shown that two axes forming a constant angle, and all lines making the same constant angle with them form a network of parallelograms. Slopes and different ratios are no longer equivalent, and difference ratios are used exclusively. But the other properties of a straight line still hold, including the various forms of the equation of a straight line, excepting the Normal or the Hessian form, which does not concern us here.

Oblique network is then used in connection with triangles and parallelograms and the following theorems are proved:

1. If a line parallel to one side of a triangle cuts the other

two sides, then any two segments on one side have the same ratio as the two corresponding segments on the other side.

2. Converse of 1.

3. A line parallel to one side of a triangle forms with the other two sides a triangle so related to the given that (1) their corresponding angles are equal and (2) their corresponding sides have equal ratios.

4. If two triangles agree in two angles, then their corresponding sides have equal ratios, or the sides of one are equimultiples of the corresponding sides of the other.

5. If the corresponding sides of two triangles have equal ratios, or the sides of one are equimultiples of the sides of the other, then the two triangles agree in their angles.

6. If two right triangles agree in one acute angle, then they agree also in the ratio of any two sides similarly situated in the two triangles.

The last theorem leads to the trigonometric functions and the solution of the right triangle by means of these functions. The trigonometric functions are also used to prove the Pythagorean theorem. This last theorem yields the distance formula in two dimensions, and this formula is used to solve loci problems.

The algebra is introduced as needed and carefully constructed on the fundamental laws. The application of the theorems stated above gives effective drill in the interpretation of geometric language and in solving equations. While practically no attention is given to puzzle problems, the problems which deal with the decimal system and commercial applications are amply dealt with. Extensive use of decimals, fractions, and per cents is made throughout.

THE USE OF THE DEFINITION IN TEACHING

By Adelphia M. Meyer
Ball State Teachers College, Muncie, Indiana

Voltaire is quoted as saying: "If you wish to converse with me, define your terms." That is just another way of saying that progress in thought cannot be made between two individuals unless they call the same things by the same names. This

whole idea has a very strategic application in teaching techniques, and is very true in the realm of biological science.

The vocabulary has always been, and I suppose always will be, a conspicuous stumbling block in the learning and teaching of biology. Naturally the teacher tends to develop some techniques that will tend to change the vocabulary from a definite obstacle to a highly valuable tool in the eyes of his students. The methods by which this transition is brought about depends upon the teacher.

On an introductory level in biology, it is found sometimes quite satisfactory for the teacher to pointedly insist that special attention be given to the vocabulary of the subject and that the student be encouraged to make a real effort to increase daily his vocabulary. In fact, in some cases it is necessary that the student make honest efforts in mastering the spelling and pronunciation. Little quizzes emphasizing spelling and pronunciation of new words have proved beneficial in stressing the early stages of mental growth along new lines. Such emphasis also stresses the fact that a conception conceived becomes tangible in communication to others usually in terms of words. So if the student chooses to express himself biologically, he is forced to master the mechanics of biological expression.

Since in general, the mechanics of biological expression are more difficult than those encountered in some other fields, a good biology teacher will not entirely eliminate all phases of word drill from teaching. This applies to all levels of biology teaching from the elementary school through the graduate school. Even a college professor should feel reasonably sure that his students are able to use biological terms in both oral and written communications.—So much for biological mechanics of expression.

Now for the consideration of the various levels of conception of the same thing. Here one finds that the interpretative nature of the teacher becomes the guiding influence in the mental growth of his students. He recognizes that the first conceptions of a term are usually quite different from those later ones. He realizes that the initial idea of the words ANIMAL and PLANT are quite different from the conception of matured biologists. His teaching experience tells him that as a student develops and his biological experiences increase in number that the word ANIMAL will come to include delicate floral types like Obelia to dynamic beasts of the savanna like the lion. He will

also know that in time the word PLANT will include the bacterium as well as the oak.

It is absolutely necessary for a teacher to know upon which levels his students are, in order that he might guide their growth to higher and broader ones. These levels are very tangibly seen on quizzes when terms are defined by students. Such definition quizzes are excellent indices of the individual and group development. The teacher is able to see to what degree he has been successful. The real purpose of such quizzes should be the guiding influence of them upon the teaching that follows. Such quizzes indicate definitely the direction that the teaching should take. Any individual who merely gives such quizzes for grades is certainly failing to appreciate ideal teaching situations.

Frequently definition quizzes can be used in order to force the student to build up an idea so that the teacher can substitute either a broader or more specialized one. Either of those can only be developed after some basic and initial one has been held. Definitions are excellent foundations upon which exceptions can be introduced. But exceptions are never completely understood in their proper perspective until the ordinary interpretations are fully apprehended.

No student can actually appreciate the place of Euglena or the spirochaetes unless in his mental growth he has passed from definite ideas of contrasts between plants and animals through stages in which he recognized the fact that some forms do not show such conspicuous contrasts. The same thing is true in developing the idea of continuity between the organic and inorganic, and animate and inanimate. An individual cannot appreciate the transitional regions unless he is absolutely sure of the features most apparent in the extremes of the series. An integrated conception of sex as exhibited in both animal and plant kingdoms certainly is reached only after the individual has fully appreciated distinct maleness and distinct femaleness. Until those are recognized, hermaphroditism, asexuality, monoecism can hardly be actually appreciated.

The definition can definitely be used as a base around which tangential, parallel, or convergent ideas may be developed. Campanella in 1590 expressed this whole thought beautifully by saying: "Definition is the end and epilogue of science. It is not the beginning of our knowing, but only of our teaching."

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting, and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Dirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

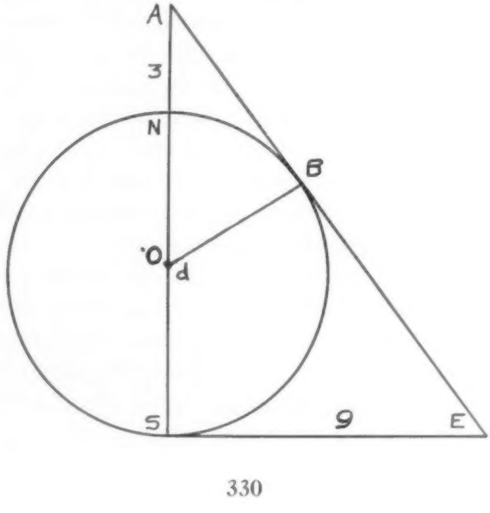
LATE SOLUTIONS

1523, 5. *Max Lipshitz, Bayonne, N. J.*

1524, 5. *J. Byers King, Corsica, Pa.*

1526. *Proposed by Chin Chin Shoo (1247 A.D.).*

There is a circular city of unknown diameter having four gates. Three miles north of the north gate is a tree which is just visible from a point nine miles east of the south gate. Find the diameter of the city.



Solution by John Driscoll, Scituate, Mass.

Let the radius of the circle $=x$; $ES=9$ therefore $\underline{BE}=9$; $AN=3$. In triangle AOB, $DO=x$, $AO=3+x$ therefore $AB=\sqrt{9+6x}$. In similar triangles AOB, and ASE

$$\frac{x}{9}=\frac{\sqrt{9+6x}}{3+2x}.$$

Solving:

$$\begin{aligned}3x+2x^2&=9\sqrt{9+6x}\\x^2(3+2x)^2&=81(3)(3+2x)\\x^2(3+2x)&=243\\2x^3+3x^2-243&=0.\end{aligned}$$

By the remainder theorem there is a root between 4 and 5. On trial 4.5 is found to check.

Therefore $x=4.5$ and diameter of circle city $=9$.

Solutions were also offered by David Rappaport, Chicago, Ill., William W. Taylor, Walter R. Warne, New York City, D. L. MacKay, New York City, G. C. Beazley, Dartmouth, Nova Scotia, Charles W. Trigg, Los Angeles, W. R. Smith, Chicago, Margaret Joseph, Milwaukee, Wis., Julius H. Hlavaty, New York City, J. Byers King, Corsica, Pa.

1527. *Proposed by Chas. P. Louthan, Cleveland.*

The sphere $x^2+y^2+z^2=100$ is cut by plane $z=8-.3x-.2y$. By use of trigonometry, find the radius of the circle of intersection.

Solution by H. R. Mutch, Glen Rock, Pa.

Using the distance formula of a plane from the origin (which involves trigonometry) gives for this distance, $8\sqrt{1.13}$. This with the radii of the sphere and circle of intersections gives a right triangle. If r is radius of this circle, we obtain

$$r=\sqrt{100-\frac{64}{100}}=\frac{7}{\sqrt{1.13}}.$$

Solutions were also offered by Charles W. Trigg and Walter R. Warne.

1528. *Proposed by David Rappaport, Chicago.*

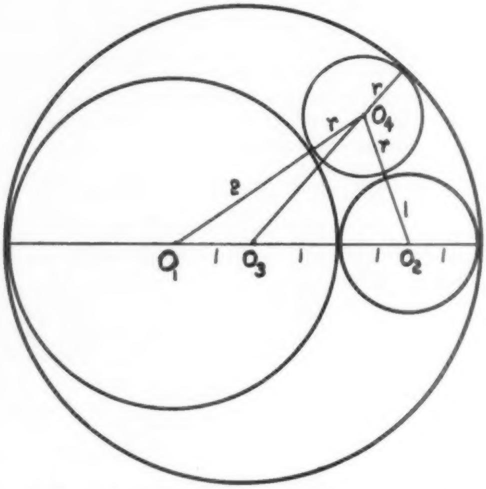
Two circles of radii one inch and two inches are tangent to each other externally. Both are tangent internally to a circle whose radius is three inches. A fourth circle is tangent to all three circles. Find the radius of the fourth circle.

Solution by Hyams Washam, Sherman, Texas

Let r equal the radius of the fourth circle. The lines of centers of the four circles will form triangles $0_2 0_3 0_4$ and $0_1 0_3 0_4$ having the same altitude, and with their bases in the ratio 2 to 1. $0_3 0_4=3-r$; $0_1 0_4=2+r$; $0_2 0_4=1+r$.

∴ Area of	$\Delta 0_2 0_3 0_4=2(\text{Area of }\Delta 0_1 0_3 0_4)$	(1)
By Hero's formula,	$\Delta 0_2 0_3 0_4=\sqrt{6r-3r^2}$	(2)
and	$\Delta 0_1 0_3 0_4=\sqrt{6r-6r^2}$	(3)
Substituting in (1):	$\sqrt{6r-3r^2}=2\sqrt{6r-6r^2}$	(4)
Squaring, we get	$6r-3r^2=4(6r-6r^2)$	(5)
Solving, we find that	$r=\frac{6}{7}$ or $\frac{0}{3}$.	

EDITOR'S NOTE: Mr. Trigg, who uses Stewart's Theorem, remarks that another circle with same radius can be drawn to meet the conditions. Julius H. Hlaraty observes "this problem is a special case of a problem attributed to Archimedes which may be found in his *Book of Lemmas*, proposition 6. (See T. L. Heath's edition of the *Works of Archimedes*, Page 307.)"

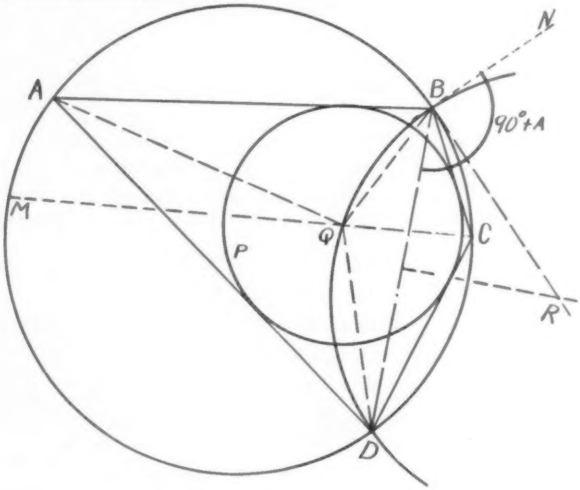


Additional solutions were offered by J. Wortman, Stuyvesant H. S., New York City, Arthur Danzl, Collegeville, Minn., J. Byers King, Corsica, Pa., V. C. Bailey, Emory, Va., and the proposer.

1529. *No solution was offered.*

1530. *Proposed by D. F. Wallace, Minn.*

Given a circle and two chords AB and AD of unequal lengths, find in the arc subtended by the angle BAD, a point C so that a circle may be inscribed in the quadrilateral $ABCD$.



Solution by V. C. Bailey, Emory, Va.

The following theorems are found in most texts on Plane Geometry:

Theorem 1. In an inscribed quadrilateral opposite angles are supplementary.

Theorem 2. In a circumscribed quadrilateral the bisectors of the angles pass through the center of the circle.

Theorem 3. On a given line segment as a chord construct a segment of a circle containing a given angle.

Suppose the problem solved. To solve this problem it is necessary to find Q the center of the inscribed circle.

Draw bisectors BQ and DQ of angles ABC and CDA, respectively. Angle BQD equals 90 degrees plus angle A.

The locus of Q, of angle BQD, is arc BQD of circle R. (Th. 3.)

Q is on the bisector of angle A. (Th. 2.) Hence, Q is determined.

The bisector of angle BCD passes through Q and the mid-point, M, of arc BAD. Therefore C is located.

Solutions were also offered by D. L. MacKay, New York, and the proposer.

1531. *Proposed by Isadore Chertoff, Bayonne, N. J.*

If the sides a, b, c, and d of any quadrilateral are in arithmetic progression, show that the

$$\text{Area} = \sin\frac{(A+C)}{2}\sqrt{abcd}.$$

Solution by Charles W. Trigg, Cumnock College, Los Angeles

It was in the shown solution to 1347, December 1934, p. 1001, that the area of any quadrilateral with a pair of opposite angles A and C is

$$\sqrt{(s-a)(s-b)(s-c)(s-d)-abcd\cos^2\frac{A+C}{2}}, \tag{1}$$

where $2s=a+b+c+d$. Since this expression is symmetrical in a, b, c and d, any side may be chosen as the shortest one, so set $a=a$, $b=a+k$, $c=a+2k$, $d=s+3k$, hence $s=2a+3k$. Substituting in (1),

$$\Delta=\sqrt{(a+3k)(a+2k)(a+k)a-abcd\cos^2\frac{A+C}{2}}$$

$$=\sqrt{abcd\left(1-\cos^2\frac{A+C}{2}\right)}=\sin\frac{A+C}{2}\sqrt{abcd}.$$

It will be noted that the proposition holds regardless of the order of the sides.

Now if $A+C=180°$, that is, the quadrilateral is inscriptible, $\Delta=\sqrt{abcd}$. So the area of an inscriptible quadrilateral is $\sqrt{abcd}$ if its sides in any order form an arithmetic progression, or if it is circumscriptible. (1459, December 1936, p. 1031).

Solutions were also offered by D. L. MacKay, New York City, Walter R. Warne, New York City, and the proposer.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems sub-

mitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below.

1526. *Arthur Bridgman, Plainville (Conn.) H. S.*, Mary Bell, Dartmouth, Nova Scotia, John Driscoll, Scituate (Mass.) H. S., Richard Slayback, Connersville, (Ind.) H. S.

PROBLEMS FOR SOLUTION

1544. *Proposed by Charles P. Louthan, Columbus, Ohio.*

In triangle ABC the side BC is bisected at E, and AB at G; AE is produced to F so that $EF=AE$ and CG is produced to H, so that $GH=CG$. Prove that F, B, H are collinear.

1545. *Proposed by Roy Mackay, Portales, New Mexico.*

For any integer A, show that

$$f(a, x)=1!2!\cdots(n-1)!n!x^{n(n+1)/2}$$

When

$$f(a, x)=\begin{vmatrix} 1 & 1 & \cdots & 1 \\ a & a+x & & a+nx \\ a^2 & (a+x)^2 & & (a+nx)^2 \\ \vdots & \vdots & & \vdots \\ a^n & (a+x)^n & & (a+nx)^n \end{vmatrix}.$$

1546. *Proposed by William W. Taylor, Port Arthur, Texas.*

Show that a triangle may be constructed, given two sides and the median to the third side.

1547. *Proposed by Charles W. Trigg, Cumnock College, Los Angeles.*

Find a number consisting of eight distinct digits such that the numbers each consisting of two different permutations of the same digits may be factored into three consecutive integers.

1548. *Proposed by Hobson M. Zerbe, Wilkes-Barre, Pa.*

In a given circle, inscribe a triangle so that one side shall be parallel to a given line and the prolongations of the other two sides of the triangle shall pass through the extremities of the given line.

1549. *Proposed by O. T. Snodgrass, Yankton, S. D.*

In the parallelogram $ABCD$, E, F, H, K are midpoints of the sides BC, CD, DA and AB respectively. If DK meets AE and CH respectively in U and R, and if BE meets AE and CH in F and S, prove that $RSTU$ is a parallelogram and equal in area to $\frac{1}{5}$ parallelogram $ABCD$.

SCIENCE QUESTIONS

March, 1938

Conducted by Franklin T. Jones

(Send all communications to Franklin T. Jones, 10109 Wilbur Avenue, S. E. Cleveland, Ohio.)

Readers are invited to co-operate by proposing questions for discussion or problems for solution.

Examination papers, tests, and interesting scientific happenings are very much desired. Please enclose material in an envelope and mail to Franklin T. Jones, 10109 Wilbur Ave., Cleveland, Ohio. Thanks!

Your classes and yourself are invited to join the GQRA (Guild Question Raisers and Answerers). More than 220 others have already been admitted to membership by answering a question or proposing one that is published.

BECOME MEMBERS OF THE *GQRA*

RAIN GAUGE

830. *Proposed by L. M. Hollingsworth, San Diego, Cal. (Elected to the GQRA, No. 216).*

"If a tall, slender, thin-rimmed top can were placed perpendicular (vertical) to catch rainfall, why would it under-measure?

PRESSURE IN AUTO TIRES

831. *Proposed by W. R. Smith (GQRA, No. 176), Lewis Institute, Chicago, Ill.*

"When an automobile weighing 3000 lbs. is jacked up off the wheels, the air pressure in the tires is 30 lbs. (per sq. in.). If the car is then allowed to rest on the tires, will the pressure in them be altered? If so, why?"

THE "TALON" OF THE "GENEVA FREE PRESS"

Through co-operation between Mr. C. A. Bonsor (GQRA, No. 126), Editor of the GENEVA FREE PRESS *and Member of the Geneva Board of Education, Mr. D. R. Frasher, Superintendent of Schools, and the Teachers and Pupils of Geneva High School, the editorial page of the* FREE PRESS *is turned over to the High School staff of the* "TALON" *every Wednesday. Editorials are written by students, news of the school is sent out to the entire community, interesting questions are asked and answered.*

832. Question—Is a similar practice carried on in other communities? If so, where? (Please send copies containing such a department to the Editor of SCIENCE QUESTIONS.)

From the January 5, 1938, issue of the TALON *the following mnemonic in blank verse style is taken:*

JUST BONES

"26 bones you have in your spine; 24 ribs and 2 more in that chest of thine; 2 bones in each shoulder, one in front, one in back; 3 in each arm to give a good whack; 8 little bones in each one of your wrists; 5 bones in each palm to make a good fist.

"28 bones in your fingers 10; 1 bone in each hip and then—1 bone in each thigh if you please; 1 bone, the knee pan, in each one of your knees; 2 bones in each leg and they are quite long; 7 bones in each ankle to make them strong; 5 bones are there in the ball of each foot; 28 bones in the toes are put; 14 bones in your dear face, 'tis said; 8 bones are there in your head; 3 bones each listening ear make—206 bones in all, my dear."

EXCHANGE OF BIOLOGICAL KNOWLEDGE

821. *From Sister Mary Stanislaus Costello, Mercy High School, Milwaukee, Wis. (GQRA No. 152).*

"The Mercy Bio-ite Club wishes to exchange biological knowledge with other Biology Clubs (or Classes) of our country."

(Dr. O. D. Frank, please note.).

Sister M. Stanislaus Costello writes as follows in part:

"Your efforts have at last been rewarded for Dr. O. D. Frank wrote to the MERCY BIO-ITE CLUB on the very day he received his SCHOOL SCIENCE AND MATHEMATICS. We responded. Within a week or so we received his BETO's, which our members enjoyed immensely.

Just at this time we had a "Theme song contest"—songs in which the students put their bits of knowledge to music. Our Secretary asked Dr. Frank if he would accept the responsibility of judging our songs. Almost immediately we received his letter of acceptance. The songs were sent to him and a week later the result came to us. We thank you for sowing the seed of biological exchanges. It will spread forth sparks of interest from all sides, I believe. Our judges were three teachers of biology: two from Chicago and one from Michigan. All voted in favor of the same song. Enclosed is a copy of the winning song.

Dr. Frank is certainly one who believes in encouraging others. I am so grateful that we are to exchange material. Quite soon our exchange will go to him and with it a flour and salt model of an apple plus a biological song about apples. No doubt he will enjoy that.

Thank you again, Mr. Jones, for we appreciate your interest in the Club of Mercy High School. Would that we could hear from other clubs! As Dr. Frank says, "It's great fun!"

Sincerely,

Sister M. Stanislaus Costello.

(*If request is received, the prize "Theme Song" will be published.*)

COUNTERCLOCKWISE ROTATION

815. *Proposed by Vernon McNeilus (GQRA No. 196), Clarion, Iowa*

"When water is poured down a drain, it naturally and invariably seems to rotate in a counterclockwise direction.

"Is this controlled by some physical law?"

Comment by L. M. Hollingsworth (GQRA No. 216), San Diego, Cal.

"The explanation of 'counterclockwise rotation' is not very informative. The side of a water drain nearest the equator has a more rapid motion than the opposite side.

"When water spreads from the center of the drain it falls behind on the equator side (either hemisphere) and gets ahead on the other side. If water were fed onto a drain on the rim at the sides mentioned, it would not rotate."

SOLUTIONS

Solutions for 822, 823, 824, 825, 826 are credited to the following: Cecil Lathrop, Science Dept., Laceyville High School, Laceyville, Pa. (Elected to the GQRA No. 219), and his pupils also elected to the GQRA—Alice Grow (GQRA, No. 220), Boyd Beeman (GQRA, No. 221), Earle Rought (GQRA, No. 222), and Clarice Severs (GQRA, No. 223).

WAVES AND VIBRATIONS

806. *Proposed by James Fitzpatrick, (GQRA, No. 192), Ringling, Okla.*

Answers by Basil C. Barbee, student, Stephen F. Austin College, Nacogdoches, Texas (Elected to the GQRA, No. 218).

"In the magazine SCHOOL SCIENCE AND MATHEMATICS for December,

1937, I noticed that you asked for an answer to question No. 806, an old problem which had not been answered. I do not know whether or not I am supposed to answer it, as I am a college student, but in case you wish my answer, here it is:

Q. 1. Is it possible to send electrical waves in a desired direction? *A.*—Yes. If electro-magnetic waves are referred to, they may be focussed much as are light waves when of a very high frequency approaching that of light, and may be directed almost at will when of a lower frequency by means of directional antennae. Electrical currents, of course, take the path of least resistance.

Q. 2. Can sound waves and vibrations be produced so large and so loud that they can destroy some solid structure? *A.*—Yes. In this part of the country, sound waves from dynamite explosions used in oil prospecting frequently break fragile articles nearby. The great tenor, Caruso, could shatter a glass tumbler by singing a loud tone to which the tumbler was resonant.

Q. 3. There is still argument as to whether or not electro-magnetic waves are transmitted by an all-pervading substance called "ether," and also just what the waves are, but theoretically there is no limit to the range of such waves, since their intensity decreases proportional to the square of the distance they travel. Thus we can readily see that no matter how far they might travel, they would still have some intensity. Practically, however, the usability of these waves for communication is limited by interference from similar waves set up by natural static or other means when they have gone so far as to be very weak. With a powerful enough source for electro-magnetic waves, there is no limit on this earth for the transmission of the waves through air.

Q. 4. Can electric waves be made to magnetize a motor and stop its running? *A.*—Yes. An enormously strong magnetic field could stop an electric motor having a relatively weak field and possibly combustion motors made of iron and steel or having electrical ignition. However, if a motor working on the Diesel principle were made from non-magnetic materials, it would be impossible to stop in such a manner except by eddy currents, which is not likely."

JOIN THE GORA!

220 others have done so!!

BOOKS AND PAMPHLETS RECEIVED

Advanced Calculus, by W. Benjamin Fite, Davies Professor of Mathematics, Columbia University. Cloth. Pages xii+399. 14×21.5 cm. 1938. The Macmillan Company, 60 Fifth Avenue, New York, N.Y. Price $5.00.

Consumer Mathematics, by Anne Louise Cowan, Ponca City Senior High School, Ponca City, Oklahoma. Cloth. Pages xiv+324. 13.5×20 cm. 1938. Stackpole Sons, 320 Telegraph Building, Harrisburg, Pennsylvania. Price $1.25.

Landslides and Related Phenomena, by C. F. Stewart Sharpe, Soil Conservation Service, United States Department of Agriculture. Cloth. Pages xii+137. 15.5×23 cm. 1938. Columbia University Press, 2960 Broadway, New York, N. Y. Price $3.00.

Handbook of Chemistry and Physics, edited by Charles D. Hodgman, Associate Professor of Physics at Case School of Applied Science. Twenty-second Edition. Cloth. Pages xviii+2069. 10.5×17 cm. 1937. The Chem-

ical Rubber Company, 1900 W. 112th Street, Cleveland, Ohio. Price $6.00 in United States and Canada, and $6.50 in Foreign Countries.

The Carbon Compounds, A Textbook of Organic Chemistry by C. W. Porter, Professor of Chemistry in the University of California, Los Angeles, California. Third Revised Edition. Cloth. Pages viii+495. 14.5×23.5 cm. 1938. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $4.00.

Elements of Statistical Method, by Albert E. Waugh, Professor of Economics, Connecticut State College, Storrs, Connecticut. Cloth. Pages xv+381. 14.5×23 cm. 1938. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $3.50.

Elementary Practical Physics, by Newton Henry Black, Assistant Professor of Physics, Harvard University, and Harvey Nathaniel Davis, President of Stevens Institute; Formerly Professor of Mechanical Engineering, Harvard University. Cloth. Pages viii+710. 13×20.5 cm. 1938. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.00.

Science in Our Lives, by Benjamin C. Gruenberg, Lecturer on the Philosophy of Science, College of the City of New York, and Samuel P. Unzicker, Formerly Vice-Principal, Roosevelt Junior High School, Fond du Lac, Wisconsin, and Lecturer on Secondary Education, Northwestern University, Evanston, Illinois. Cloth. Pages xiv+750. 13×19 cm. 1938. World Book Company, Yonkers-on-Hudson, New York, N. Y. Price $1.76.

A Technique for Appraising Certain Observable Behavior of Children in Science in Elementary Schools, by Joe Young West, Ph.D. Contribution to Education, No. 728, Teachers College, Columbia University. Cloth. Pages vii+118. 15×23 cm. 1937. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $1.60.

The Progress Arithmetics, Book E, by Philip A. Boyer, Director, Division of Educational Research, Philadelphia Public Schools; W. Walker Cheyney, Elementary Research Supervisor, Philadelphia Public Schools; and Holman White, Superintendent, District 9, Philadelphia Public Schools. Paper. 189 pages. 20×28 cm. 1938. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price 48 cents.

Living Safely, by Earl C. Bowman, Director of Student Teaching, De Pauw University, Greencastle, Indiana, and Paul F. Boston, Superintendent of Schools, Greencastle, Indiana. Paper. 177 pages. 20×28 cm. 1938. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price 52 cents.

Laboratory Manual for Unified Physics, by Gustav L. Fletcher, Chairman, Department of Physical Science, James Monroe High School, New York City, and Sidney Lehman, Department of Physical Science, James Monroe High School, New York City. Paper. Pages xiii+210. 19×27 cm. 1938. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price 88 cents. Cloth $1.04.

An Elementary Course in Qualitative Analysis, by William Lloyd Evans, Jesse Erwin Day, and Alfred Benjamin Garrett, The Ohio State University. Paper. 233 pages. 19.5×26.5 cm. 1938. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $2.00.

Mathematics for Electrical Students, by Harry M. Keal, Head of Mathematics Department, Cass Technical High School, Detroit, Michigan, and Clarence J. Leonard, Head of Mathematics Department Southeastern High School, Detroit, Michigan. Second Edition. Cloth. Pages vii+225. 12×18 cm. 1938. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $1.60.

Mathematics for Shop and Drawing Students, by Harry M. Keal, Head of Mathematics Department, Cass Technical High School, Detroit,

Michigan, and Clarence J. Leonard, Head of Mathematics Department, Southeastern High School, Detroit, Michigan. Second Edition. Cloth. Pages vii+225. 12×18 cm. 1938. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $1.60.

Technical Mathematics, Volume I, The Equation, the Formula, and the Graph. Pages vii+246. Price $1.25. *Volume II, Geometric Proof, and Use of the Natural Functions.* Pages ix+277. Price $1.50. *Volume III, Trigonometry, Applied Problems, and the Slide Rule.* Pages vii+149. Price $1.25. Second Editions. Cloth. 12×17.5 cm. 1938. Written by Harry M. Keal, Head of Mathematics Department, Cass Technical High School, Detroit, Michigan, and Clarence J. Leonard, Head of Mathematics Department, Southeastern High School, Detroit, Michigan. John Wiley and Sons, 440 Fourth Avenue, New York, N. Y.

Elementary Mathematical Analysis, by Theodore Herberg, Head of Mathematics Department, Pittsfield High School, Pittsfield, Massachusetts. Cloth. Pages v+120. 14×21 cm. 1938. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $1.24.

New Analytic Geometry, by Percey F. Smith, Professor of Mathematics in the Sheffield Scientific School of Yale University; Arthur Sullivan Gale, Professor of Mathematics in the University of Rochester; and John Haven Neelley, Professor of Mathematics in the Carnegie Institute of Technology. Alternate Edition. Cloth. Pages x+336. 12.5×19 cm. 1938. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $2.00.

The Problems of Education, A First Course for the Orientation of Prospective Teachers, by Claude C. Crawford, Ph.D., Author of "The Technique of Study," and Co-author of "Modern Methods in Teaching Geography," etc.; Louis P. Thorpe, Ph.D., Author of forthcoming "Psychological Foundations of Personality"; and Fay Adams, Ph.D., Author of "The Initiation of an Activity Program into a Public School," and Co-author of "Teaching the Bright Pupil" and "Story of Nations." (All of the University of Southern California). Cloth. 239 pages 12.5×18.5 cm. 1938. Southern California School Book Depository, Los Angeles, Calif. Price $2.50.

How to Teach, A Text for Upper Grade and Secondary Teachers, by Claude C. Crawford, Professor of Education, University of Southern California. Cloth. 511 pages. 12.5×18.5 cm. 1938. Southern California School Book Depository, 3636 Beverly Blvd., Los Angeles, Calif. $2.50.

Theory and Applications of Finite Groups, by G. A. Miller, Professor of Mathematics in the University of Illinois; H. F. Blichfeldt, Professor of Mathematics in Stanford University; and L. E. Dickson, Professor of Mathematics in the University of Chicago. Reprint of 1916 Edition with Corrections. Cloth. Pages xvii+390. 13.5×21.5 cm. 1938. G. E. Stechert and Company, 31 East 10th Street, New York, N. Y. Price $4.00.

Number-System of Algebra, by Henry B. Fine, Professor of Mathematics in Princeton College. Reprint from 1890 Edition. Cloth. Pages ix+131. 12.5×19.5 cm. 1937. G. E. Stechert and Company, 31 East 10th Street, New York, N. Y.

The Queen of the Sciences, by E. T. Bell, Professor of Mathematics in the California Institute of Technology. Cloth. 138 pages. 12.5×19.5 cm. 1938. G. E. Stechert and Company, 31 East 10th Street, New York, N. Y.

Commercial Trucking of Fruits and Vegetables in Nine Atlantic Coast States, by Nephtune Fogelberg, Senior Agricultural Economist, and Herbert W. Mumford, Jr., Associate Agricultural Economist. Bulletin No. 17. September 1937. Paper. 14.5×23 cm. Farm Credit Administration, Cooperative Division, Washington, D. C. For sale by the Superintendent of Documents, Washington, D. C. Price 10 cents.

Use of Motortrucks in Marketing Fruits and Vegetables, by Marius P. Rasmussen, Professor of Marketing, New York State College of Agriculture, Cornell University. Bulletin No. 18. September 1937. Paper. 14.5×23 cm. Farm Credit Administration, Cooperative Division, Washington, D. C. For sale by the Superintendent of Documents, Washington, D. C. Price 15 cents.

Cooperative Fluid-Milk Associations in Iowa, by Paul E. Quintus, Research Assistant Professor in Agricultural Economics, Iowa State College of Agriculture, and T. G. Stitts, Principal Agricultural Economist, Farm Credit Administration. Circular No. C-105. September 1937. Paper. 14.5×23 cm. Copies of this publication may be obtained upon request from the Director of Information and Extension Farm Credit Administration, Washington, D. C.

BOOK REVIEWS

Methods in Biology, by Alfred C. Kinsey, Professor of Zoology, Indiana University, Bloomington, Indiana. Cloth. Pages x+279. 13.5×20.5 cm. 1937. J. B. Lippincott Company, 220 North Michigan Avenue, Chicago, Ill. Price $2.50.

The biology teacher of limited experience will find this book especially helpful; it is written primarily for him. The experienced teacher will find it an unbiased and interesting discussion of his own problems, with conclusions which are not likely to differ greatly from his own. The administrator in high school, college, and university charged with making decisions regarding the organization of departments and courses in biology and its special branches will be impressed with the soundness of the views.

On controversial questions such as the relative merits of Laboratory vs. Demonstrations; Applied Science vs. Pure Science; Unified Courses vs. Divided Courses; Old Type Examinations vs. New Type Examinations, etc., the author presents fairly the arguments on both sides. He does not hesitate, however, to express his own opinions. And his opinions are the more valuable in that they are backed by long experience as a teacher in high school and university, as an investigator, and as a textbook writer. As a sample of the point of view of the author on some of the live issues of today the following are selected: survey courses as an introduction to biology are superior to restricted courses; the principles course in biology is preferable to the type study course and the systematic course; it is not a laboratory science but an out-door biology that the average student in our elementary classes needs; the average text in college biology is poorly written, and many of the high school books are more lucid and some are attractive in style; new type (objective) tests alone are inadequate due to their over emphasis on memory of facts, and some of them, such as true-false and multiple choice tests, are objectionable on account of the element of guessing.

Extensive lists of references to periodicals, textbooks, and books on special subjects are given at the end of each chapter. There is an index.

EDWARD C. COLIN

Science in the Elementary School, by W. C. Croxton, Ph.D., State Teachers College, St. Cloud, Minnesota. Cloth. Pages ix+454. 1937. McGraw-Hill Book Co., New York, N. Y. Price $3.00.

The rapid development of science in the elementary schools has raised many problems for teachers in the selection and organization of content and in methods of teaching. Many teachers have found it necessary to undertake the teaching of elementary science without adequate prepara-

tion. These science teachers have been looking for a book that would help them solve these new problems they are facing. At last the book they have been looking for has appeared. It is—"Science In The Elementary School" by Croxton.

In Part I the author devotes eight chapters to the explanation of a philosophy of education which will help teachers of elementary science; to the place of science in the elementary school; to aims in science teaching; to the importance of method; to science in our changing elementary curriculum; to appraising the results of our teaching; to preparing teachers to teach elementary science and to a thorough summary and digest of recent investigation in the field of elementary science.

In Part II many worth-while suggestions are given for organizing and conducting an activity program. The activities are divided into three groups; autumn, winter and spring. There are 102 activities in all. Aims are given for each activity. These aims are followed by suggestions for teaching these activities. The suggestions are followed by contributing learnings. A complete list of references is also included with each activity.

This book will give teachers many specific helps for their daily classroom problems. It will give them a source of information they cannot possibly find in any other book. It is a book the teachers of elementary science will find exceedingly practical and usable.

IRA C. DAVIS

The Teaching of Physical Science in the Secondary Schools of the United States, France and Soviet Russia, by Alexander Efron, Ph.D., Teachers College, Columbia University, Contributions to Education, No. 725, 1937. Cloth. Price $2.35.

This investigation was undertaken to (1) discover the salient characteristics of the teaching of the physical sciences in the secondary schools of the United States, France and Soviet Russia; (2) to evaluate and compare they types of teaching procedures used; and (3) to determine the possible implications of foreign practice for physical science teaching in the United States.

Preliminary investigations established the equivalence of groups and the courses of study for the secondary schools of the United States, the schools of the second level of France and the six year secondary schools of the Soviet Union.

The investigation is based on a seven month resident study in France and Soviet Russia in 1935. Observations were made of 36 full period classes in physics and chemistry in France and 21 in the U.S.S.R. Inspections were made of their laboratory and demonstration equipment. Conferences with school officials and visits to teacher training institutions helped the author to obtain a thorough understanding of the many problems faced by the foreign schools.

The observations made are based on the philosophy of these school systems; on the content and organization of courses of study; the training of science teachers, the nature of tests and examinations, the character of textbooks; the methodology of science teaching; the conduct of extracurricular science work and the design and utilization of science equipment.

The interpretative summary gives an excellent comparison of these school systems. It is difficult to draw many specific conclusions from an investigation like this because of the wide differences in points of view and in philosophies of education. After reading this thorough investigation you are convinced that while our science program in the United States may not be the best that exists, nevertheless, it is at least the equal of any other country.

IRA C. DAVIS

Cleanliness and Health. Pages vii+236. Price 80 cents. *Health*. Pages vi+231. Price 72 cents. Third Editions. Cloth. 12.5×18.5 cm. 1937. Written by C. E. Turner, Professor of Biology and Public Health, Massachusetts Institute of Technology, Cambridge, Mass., and George B. Collins, Instructor in Health Education, Rochester Athenaeum and Mechanics Institute, Rochester, N. Y. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass.

In this series of books the author attempts to make the child aware of the marvelous handiwork nature has begot in his body and how to take the proper care of it rather than to have him acquire the knowledge of anatomical facts.

The approach to the study of hygiene is made stimulating to the child by suggestive questions, short comparative stories for illustrating a point, popular sports or terms of interest for demonstration, and a number of pictures and diagrams. Although emphasis is placed on the pride of physical perfection, consolation and help are offered those who may be unfortunately weak.

The first book of this series, *Health*, is an explanation of the body and hygienic methods for keeping it fit. Comparison of the body to a ship makes an effective appeal through the text. Illustrations showing the likeness of the telephone to the ear and the camera to the eye are worthy of note.

Cleanliness and Health, the second book of the series, goes more into detail concerning the anatomy of the body but manages to build up an interest in those principal parts; namely, structure of the skin, breathing facilities, and digestive organisms.

Health habits and correction of harmful practices are stressed in each book.

The series is attractively bound in volumes suitable for a child's hands and both paper and type are well adapted to the young student. At the end of each chapter further impression is made on the pupil's mind by the related interesting things to do plus review questions.

MARIE SHIELDS

Manual of Mathematics and Mechanics, by Guy Roger Clements, Professor in the Department of Mathematics, United States Naval Academy, and Levi Thomas Wilson, Professor in the Department of Mathematics, United States Naval Academy. First Edition. Cloth. Pages vii+266. 15×23 cm. 1937. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $2.50.

This manual or handbook for engineering students contains all the tables and formulas used in the regular mathematics and mechanics courses. The usual numerical tables and a table of 362 integrals make up the first 125 pages. These tables are followed by a rather detailed outline of series, formulas of plane and solid geometry, algebra, complex numbers, trigonometry, hyperbolic functions and analytical geometry both plane and solid including several pages of curves and their equations. An outline of differential and integral calculus, differential equations, and vectors occupies 35 pages. The remainder of the book outlines the principal topics of mechanics and gives tables of the properties of areas, bodies of constant density, and materials. The flexible binding, convenient arrangement of content, and a degree of accuracy commensurate with the limits of practical measurement are commendable features.

G. W. W.

Sound Waves Their Shape and Speed, by Dayton Clarence Miller, Professor of Physics, Case School of Applied Science, Cleveland, Ohio. Cloth. Pages xi+164. 14×21.5 cm. 1937. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.75.

About thirty years ago the author of this book invented a very clever device for the study of tone—the phonodeik. This instrument was first applied to the study of musical sounds and later to sound ranging in the World War. Of interest to the theoretical scientist is the difference in velocity of an explosive sound wave and a normal sound wave, a study also made possible by the phonodeik. The first part of the book consists of a discussion of the theory, construction and use of this instrument. An interesting chapter on the shapes of sound waves and another on recording sound waves by spark photography follow. The second half of the book describes the wartime experiments on sound waves set up by artillery and the scientific results of these studies. The book is written in non-technical language and is profusely illustrated thus making it interesting to both the scientist and the layman.

G. W. W.

Man's Physical Universe, by Arthur Talbot Bawden, College of the Pacific, The Stockton Junior College. Cloth. Pages xvii+812. 14×21.5 cm. 1937. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.50.

This text is planned to serve as a text in a survey course in physical science in a program of general education. The author has drawn on his own extensive experience in teaching such a course to guide him in the selection and presentation of his material. The author of a text serving as a survey of the physical sciences has a formidable task in the selection of material taken from the fields of chemistry, physics, geology and astronomy, and organizing them into an integrated whole, but Professor Bawden has succeeded very well. He has without hestitation cut across these fields to select and organize material into ten units designed to be the basis of a program of study extending through a college year. There is an amazing amount of factual material presented in these units. The treatment is largely descriptive and the use of formalized mathematics in the form of equations or proportions is avoided entirely.

The author has continually emphasized the applications of the physical sciences, and the social and economic results of these applications. Unit III which deals with the earth, for example, closes with a discussion of the relation between our abundance of natural resources and the industrial supremacy of our nation. Unit V, on energy, discusses the Otto cycle and Diesel cycle engine in detail in connection with the topic of transportation. Unit X is devoted entirely to the topic, 'The Control of the Power of Physical Science Presents a Challenge to Man.' The reviewer has seen no text of this general type that has placed so great an emphasis on the subject of the influence of modern science on society.

There is an extensive use of teaching aids as illustrations and diagrams, which are well selected and instructive. Each chapter closes with a list of study questions to guide the student in the mastery of content material.

It is too much to expect that one writer covering the fields of chemistry, physics, geology and astronomy could avoid mistakes of fact, interpretation and manner of statement. The author in his preface frankly anticipates that this will be true and requests that readers submit 'helpful criticism.' The reviewer hopes that the next edition of this text will be much improved by elision or correction of certain statements made throughout the

book. To aid in this task, the reviewer makes the following additional comments:

1. The author at times makes statements that might have serious consequences. Thus on page 508, there is a statement that '110 volts is harmless'; on page 279, there is a statement which would cause a reader to infer that it is possible to plunge an arm into a pot of molten iron with no harmful consequences.

2. The whole text should be re-examined from the standpoint of proper use of English. There are entirely too many mistakes in English, such as, 'steady and ever-accelerating progress,' p. 31; 'increasingly more saturated,' p. 180; 'one hundred per cent saturation,' p. 180; 'CO is carbon monoxide,' p. 570, etc.

3. The chapter on the scientific method, Section I of Unit I, should be revised to show more clearly the relationships between scientific laws, hypotheses and theories. The author has unnecessarily confused the relationships between laws, hypotheses and theories.

4. There are many serious mistatements of fact: The oceans on Mercury 'must consist of molten lead, bismuth, sulfur,' p. 107; Mars owes its color to its 'surface colored red with oxides of iron,' p. 112; Jupiter has a red spot on its surface that 'is solid, frozen ammonia,' p. 114; thermocouples 'consist of two strips of metal with different coefficients of expansion,' p. 273; certain 'types of thermostats make use of thermocouples,' p. 273. On page 376, a bold face paragraph heading infers that internal combustion engines are not heat engines.

5. There are unfortunate statements in which the author undoubtedly did not state what he intended to state. Thus on page 373, one reads, 'a perpetual motion machine is a machine that would run indefinitely without doing any work'; a base 'neutralizes salts' on p. 633; on page 672 one reads of the 'oxidation of sodium sulfate'; 'the entire surface of the moon has been photographed,' page 108; the fluidities of liquids are a 'measure of their rates of diffusion,' page 256; the Gregorian calendar provides for fewer leap years than the Julian calendar, instead of more, as stated on page 134, etc.

Survey courses in physical sciences are too new to have reached the state of being standardized. The present book will not appeal to those teachers of science survey courses who wish an emphasis placed on the great and far-reaching generalizations of modern science, with an explanation of the experimental bases for these generalizations. Those teachers who feel that the function of a science survey course is to present a body of fact content suitably organized and a discussion of scientific laws and theories and the applications of science will want to examine this volume by Professor Bawden.

C. E. Ronneberg

Chemistry and Cookery, Some Theories of Chemistry and Applications to Cookery Processes, by Annie Louise MacLeod, Ph.D., Dean of the College of Home Economics, Syracuse University, and Edith H. Nason, Ph.D., Professor of Foods, Syracuse Uhiversity. Second Edition. pp. xiv+568. 3.5×15×21 cm. 25 figures. Cloth. 1937. $3.50. McGraw-Hill Book Co.

Those who are familiar with the first edition of this text are aware that the authors boldly began their teaching of general chemistry by introducing some of the less debatable parts of the electronic theory of the structure of atoms. The new edition continues this method and also uses the newer conceptions of the nature and mechanism of electrolysis and of the dissociation of acids, bases and salts without delaying the game by first giving

the historical conceptions of Arrhenius and then modifying them. While something is lost by this method much is gained in a text that is primarily intended to deal with *cookery*. The essentials of general chemistry are concisely given in fewer than 200 pages after which the elements of general organic chemistry are given in about 100 pages. All along many applications to cookery are brought in "if, when and as" they fit the situation. The student is thus compelled to apply his new knowledge to situations that concern him in his major interest.

The long remainder of the text makes formal study of the commoner food products such as flour, proteins, eggs, meat, vegetables, milk, beverages etc. A brief study of the teaching method shows it to be excellent.

FRANK B. WADE

A First Book in Chemistry, by Robert H. Bradbury, Ph.D. Third Edition. 1938. pp. xv+639. 3.5×14×21 cm. 317 figures. Cloth. 1938. D. Appleton-Century Co., Inc.

Here is a really up to date revision of an excellent textbook of chemistry. From much use of an older edition the reviewer has found the method of presentation of the author to be most teachable. This is especially true of the way in which the *general chemistry* as distinguished from the *inorganic chemistry*, is presented. (The reviewer wonders if we teachers of chemistry would not do a better job of educating our students if we confined our efforts almost exclusively to the more limited field of general chemistry).

In the new edition the more recent views in regard to the structure of the atom are introduced as early as possible and thereafter used consistently as need requires. Controversial views in regard to sub-atomic structure are avoided.

The industrial chemistry portions of the book are excellently given and have been brought up to date as far as is at all possible with a subject of this type. No more will the foreman of a metallic sodium plant be able to say to a student of this text, as he did in another case, "Why I haven't used that method for 18 years!"

For those who would expose their non college entrance students to much material that is related to daily life there is abundance of descriptive matter, well illustrated, in the last 300 pages of the text. Simple organic chemistry, food chemistry (with vitamin values) metallurgy of both ferrous and non ferrous metals, petroleum chemistry etc., etc., are all well handled.

Teachers contemplating a change in text should by all means have a look at this latest revision.

FRANK B. WADE

Electricity and Magnetism for Engineering Students, by A. W. Hirst, Chief Lecturer in Electrical Engineering College of Technology, Leicester. Cloth. Pages xv+388. 14.5×22 cm. 1936. Messrs. Blackie and Son, Limited, 50 Old Bailey, London, E.C.4. Price 15s. net.

A number of textbooks on electricity and magnetism have been compiled for the student in the second year of electrical engineering. These texts in general tend to treat the content from a theoretical rather than from a practical point of view. Because the engineering curriculum is crowded with courses students get lost in the theory and attempt to get through by memorizing formulae for solving problems. The author evidently feels that they soon lose the fundamental principles to which they must refer in order to master the more complex situations. For this reason a minimum of theory is included but many references have been given for the purpose of guiding the student when it is necessary to fall back upon

the fundamental principles. The book contains more material than can be covered in the usual course and so the text may be equally valuable as a reference.

In general the chapter arrangement follows the classical. Wherever calculus has been introduced it is printed in small type so that it may be conveniently omitted. There are 388 pages divided into 16 chapters, a section of solutions to problems, and an index. A reasonable number of problems are included at the end of each chapter with answers in the rear of the text. The binding, paper, and print are to be commended.

L. C. Warner

ABSTRACT OF THE REPORT OF THE DIRECTOR OF HIGH SCHOOL RELATIONS COMMITTEE OF THE OKLAHOMA ACADEMY OF SCIENCE

February, 1935–December, 1937

By Edith R. Force,

Director, Tulsa, Oklahoma

Feb., 1935—Director of H. S. Relations appointed by Executive Council Dr. Frank Brooks, appointed Advisor, for indefinite time. When he left the city, Dr. Otto Smith served temporarily, and then Professor H. D. Chase assumed the responsibility at the request of Dr. Harper.

The Director was asked to sit with the Executive Council and plan effective work to the end that: (1) the interest of both the teachers and students of the secondary schools be enlisted in the work of the Academy of Science; (2) by cooperative efforts there shall be better science teaching and more vitally enthusiastic students of science in Oklahoma.

After study of the work in other states, an organization called "The Association of Science Students of the Oklahoma Academy of Science," by vote of the Council, was set-up. The Director was appointed chairman and advised to choose Regional Chairmen who were geographically located in the state for effective work of the affiliation of science clubs. These Chairmen were sanctioned by the Council. The purpose of research and the field of individual science endeavor was stressed with each local science club upon affiliation with The Association. . . . Altho first presented to the Academy in 1930 by the A.A.A.S. this work is still considered temporary in Oklahoma. Many of the activities of the High School Relations Committee have immeasurable results, yet the following is submitted, in part as evidence of accomplishments of this committee:

I. Growth

1. New Academy members 32, i.e., 5 Associates and 27 teachers
2. Chartered Clubs 20—14 towns—23 sponsors—about 800 students (Report incomplete from 12 clubs, due to the effort to make school year the basis for collecting dues.)
3. Regional Chairmen—7—in all O.E.A. District except Panhandle
4. Of 86 counties and units of O.E.A. 60 or 41% were contacted

II. Publications

1. News Notes: 1936—3 issues, 35 pp.; 1937—4 issues, 49 pp.—250 each
2. Supplementary aids: Reprints, club helps, teacher aids, research dealing with wildlife of state, Science Club Service (Illinois), St. Louis Jr. Academy of Science paper, Roster of clubs and Academy members (1937) according to towns, list of 34 speakers with 101 topics for affiliated

clubs from Academy membership, largely. (Samples of aids in Scrap Books).

3. Literature exchanged with 15 states on Jr. Academy work.

4. Articles published 1936—19; 1937—16 in 9 different national magazines and newspapers including Oklahoma Teacher, re: activities of science clubs in Oklahoma.

5. Responses made to inquiry for aids to 58 non-Academy members in Feb. 1936 and to 28 in Sept. 1937 accompanied by postage.

III. Correspondence and Activities

1. Talks given an Association work, upon request, at St. Louis, '35, State O.E.A., Feb. '36; East central Dist., Ada, Oct., 36; State O.E.A. Feb., '37; Northeast District, Oct. '37. Texas Academy, '37.

2. Trips made in interest of Academy: Academy Conference, St. Louis 1935; All Executive meetings—10—since 1935; 4 Regional Comm. meetings; two annual and 2 spring meetings. Dallas, Nov. '37.

3. Exhibits—Wilson Jr. High for O.E.A. meeting and at Science Section Academy meetings, 1936 and 1937.

4. Contacts with scientific apparatus companies for commercial exhibits

5. Keep Card Index of 258 live cards—204 Oklahoma; 53 from 15 states.

6. Keep all letters answered and filed with replies.

7. Assisted in collection of dues, stimulating interest in Academy and organization of science clubs with teacher aids for science.

Summary:

Many intangible things can not be recorded accurately. For example, the tones of encouraging letters; the thanks for assistance in teacher aids; the recognition of college students who have graduated and gone to teaching becoming club sponsors after Academy membership of college years; the response of Journals and out of state leaders in desiring information about methods of work in Oklahoma. Contacts with something over 1000 students who carry membership cards of The Association of Science Students of the Oklahoma Academy of Science. This is training in Academy aims and purposes which will always direct student interests as the scientists of tomorrow. The number of students who have come two to four times to the Academy meetings in the last two years is noticeable Dr. O. Smith speaks of it as being "High School Conscious."

NEW FEATURES FOUND ON MOON

Revision of our maps of the moon may be necessary as a result of the discovery of a series of craters and walled plains, near the edge of our satellite's visible disk by H. Percy Wilkins, British astronomer, who reports his new discoveries in the *Journal of the British Astronomical Association.*

Occupying twenty degrees of latitude on the southeast edge of the moon, this tangle of walled valleys, craters and high peaks has escaped discovery for many years, chiefly because nobody looked there carefully enough until now. Commenting on Mr. Wilkins' discovery, Dr. Walter Goodacre, acting director of the Society, recommended further observations of the moon's edges, which may lead to additional discoveries.

IRON

Spongy iron that is soft and malleable like lead and employable for some of the same purposes has been developed by a physicist, Dr. Hans Vogt, after many years of effort. The material has the further advantages that it is much lighter and lower in price.

One of the common uses of lead is for packing around iron plumbing; it is hammered into joints between the pipes. The new spongy iron is very well adapted for this use.

This "kneadable" iron is made by sintering powdered iron at a temperature of from 1200 to 1300 degrees Centigrade, in an atmosphere of hydrogen to prevent the formation of oxides. The product is full of tiny cavities, to which it owes its plastic properties.

COMPOUND POISONOUS TO BIRDS AND MAMMALS DOES NOT HARM INSECTS

Gossypol, a poisonous compound found in the cotton plant, proved a dissappointment when tried on insects, report Dr. E. P. Breakey and H. S. Olcott of the Mellon Institute of Industrial Research, in a recent issue of *Science.*

The cottonseed industry of this country could yield from 40,000 to 80,000 tons of this compound, it is estimated. Because it is deadly to warm-blooded animals, hopes were entertained of using it as an insecticide. However, experiments on woolly aphids and Mexican bean beetles showed that these pests could "take it" and come right back asking for more.